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AN OVERVIEW OF THE COMMERCIAL NAVIGATION INDUSTRY OF THE UNITED STATES ON THE GREAT LAKES

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The objective of this report is to provide a comprehensive overview of the role of the Great Lakes as part of the waterways transportation system of the United States. Primarily, the Lakes serve as a route for U.S. domestic commerce and translake trade with Canada. This report focuses on use of the Lakes for U.S. domestic commerce, how the Lakes function for interlake and intralake transportation, and the U.S. government and private entities that provide related transportation services and ports and waterways infrastructure. Where relevant, Canadian interests are addressed in the report.

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The report was initially prepared by Dr. Raymond W. Waxmonsky, assisted by Roger Haberly, under the supervision of Ronald Guido, Chief of the Economics Section, Planning and Engineering Division, Buffalo District.

The original draft was modified based on comments obtained from a variety of Corps offices. The final version subsequently was modified by the Navigation Division, Institute of Water Resources. Because varied offices and individuals had input into the report, it is not possible to attribute responsibility to any one individual.

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of this report is to provide a comprehensive overview of the role of the Great Lakes as part of the waterways transportation system of the United States. Primarily, the Lakes serve as a route for U.S. domestic commerce and translake trade with Canada. To a lesser extent, in combination with the St. Lawrence Seaway, the Lakes provide a route for trade with Canada and a relatively small amount of direct U.S. overseas trade. Accordingly, this report focuses on use of the Lakes for U.S. domestic commerce, how the Lakes function for interlake and intralake transportation, and the U.S. government and private entities that provide related transportation services and ports and waterways infrastructure. Where relevant, Canadian interests are addressed in the report.

CONTENTS

The report contains nine chapters and three appendixes. Each chapter describes a specific aspect of the waterway. The chapters are organized in a logical progression; the topics covered are as follows:

1. Introduction. This chapter provides the objective of the report and it identifies the individual topics that are discussed. It also provides an overview of the United States inland waterway system. Historical statistics on the performance of the inland waterways vis-a-vis competing land modes of transportation are presented and discussed.

2. Historical and Institutional Perspective. This chapter sketches the historical development of commercial navigation on the Great Lakes. It also identifies the major governmental and private sector organizations that have a significant role in the functioning and maintenance of the system.

3. Geography of the Great Lakes. This chapter discusses the geographic setting of the Great Lakes with an emphasis upon the physical geography of the lakes and connecting channels. Related topics of variation in lake levels (water surface elevations), lake level regulation and constraints to commercial navigation are discussed.

4. Great Lakes Fleet. This chapter addresses the commercial navigation fleet that operates on the Great Lakes. The composition of the fleet by nation, vessel type and vessel size

are discussed. The effect vessel size has upon unit transportation costs is illustrated.

5. Commodity Flows. This chapter provides a description of commodity flows across the Great Lakes; only bulk commodity flows are examined. Each major bulk commodity transported on the lakes is examined. Because the transportation of iron ore is critical to continued maintenance of a viable waterborne transportation industry on the lakes, the viability of the steel industry in the Great Lakes Basin is examined. The most recently published forecasts of traffic projections on the lakes through the year 2000 are evaluated.

6. Harbors. This chapter address the commercial harbors on the Great lakes within the United States. It provides historical data for the recent past on the volume of freight transported through each U.S. commercial harbor. The distinction between private and federal harbors is presented. Harbors are categorized by depth and additionally a rank order of harbors organized by volume of commodities transported in 1989 is presented.

7. Operations and Maintenance. This chapter presents an overview of Federal operations and maintenance expenditures on the Great Lakes. Historical data are presented and trends in that data are identified. An index of operations and maintenance expenditures per ton of traffic is presented for each commercial harbor. The recently implemented Harbor Maintenance Fee is discussed.

8. Other Topics. This chapter reviews the confined disposal facility program of the Army Corps of Engineers. Data on the location and capacity of all Federal confined disposal facilities on the lakes is presented and the adequacy of current authorizing legislation is reviewed. Active Army Corps of Engineers studies and projects are identified and discussed.

9. Conclusions. This chapter summarizes significant points identified in the review of the Great Lakes Navigation System.

CHAPTER SUMMARIES

Chapter 1. Introduction

The Great Lakes-St. Lawrence Seaway System is one of three components of the U.S. Waterways Transportation System. The other two components are the Deep Draft Coastal Ports and Related Waterways, and the Shallow Draft Inland and Intracoastal Waterways.

Primarily, the Lakes and Seaway serve as a route for U.S. domestic commerce and trade with Canada. Predominantly, that commerce is within the Lakes. A combination of size constraints due to lock dimensions and the depth of connecting channels, plus the sometimes boisterous weather and wave conditions on the Lakes, has produced a unique vessel type serving the Lakes. The largest of those vessels cannot go below the Upper Lakes. Conversely, the lock sizes on the Seaway preclude entry into the Lakes by the largest seagoing vessels, an impediment to sustaining a large volume of direct overseas trade. The result is that the Lakes are a distinct subset of the U.S. waterways system. The ports and waterways infrastructure required to support Great Lakes commerce is substantial, and similar to deep draft coastal ports.

Shipments of intercity freight by water has grown since World War II, but the growth of water shipments has been substantially below that of shipments by land transportation modes. Shipments of intercity freight on the Great Lakes has not grown; it has declined. Thus while the Great Lakes accounted for about one-third of all waterborne intercity freight shipments in 1947-49, they accounted for 10% to 11% in 1988-90.

Chapter 2. Historical and Institutional Perspective

Various dates may have been used to mark the commencement of commercial navigation on the Great Lakes, but it was not until 1855 that all five lakes and the St. Lawrence River were connected into a navigable commercial waterway system. It was two more recent events, construction of the new Welland Canal in 1932 and the opening of the St. Lawrence Seaway in 1959, which produced the system as it exists today.

The Great Lakes are an international waterbody shared by Canada and the United States. The two countries have established an agency, the International Joint Commission, to address cross-boundary natural resource issues. The agency also has the authority to regulate Great Lakes levels and flows, and means to do so to some extent on Lake Superior and on Lake Ontario and the St. Lawrence River.

A combination of private enterprise and governments operate and maintain the Great Lakes Waterway. Private enterprise operates all commercial vessels on the lakes. Private enterprise also owns and operates the vast majority of bulk terminal facilities; most general cargo terminal facilities are owned and operated by local governments or local port authorities. A significant number of harbors, some of which originate large tonnages of traffic, are privately owned and operated. Private enterprise is represented by the Lake Carriers Association which is the spokesman for the U.S. shipping companies operating commercial navigation fleets on the lakes.

The U.S. Government has a major role in developing, operating and maintaining the Great Lakes Waterway. The U.S. Army Corps of Engineers has the basic responsibility of facilitating vessel movements by planning, constructing, operating and maintaining federal channels, harbors and locks. The U.S. Coast Guard and the Maritime Administration also have a direct role in maintaining commercial navigation on the waterway. The St. Lawrence Seaway Development Corporation, a wholly governmental owned corporation administered under the Department of Transportation, along with the Seaway Authority of Canada operate and maintain the St. Lawrence Seaway. The Environmental Protection Agency, through its charge to maintain water quality standards, has an indirect role in affecting commercial navigation on the lakes.

Chapter 3. Geography of the Great Lakes

The Great Lakes Waterway consists of the five Great Lakes - Superior, Michigan, Huron, Erie and Ontario - and the four natural connecting channels. The flow of water in the lakes is in general from west to east; water flows from Lake Superior into Lake Huron; it flows from Lakes Michigan and Huron into Lake Erie; in turn Lake Erie flows into Lake Ontario. Water flows out of Lake Ontario to the Atlantic Ocean via the St. Lawrence River.

There are four natural interconnections between the Great Lakes; they are termed "connecting channels:" 1. St. Marys River, which connects Lakes Superior and Huron;
2. Straits of Mackinac, which connects Lakes Michigan and Huron;
3. Detroit - St. Clair River System, including Lake St. Clair, which connects Lakes Huron and Erie; and, 4. Niagara River, which connects Lakes Erie and Ontario.

All but the Niagara River are a connection for purposes of commercial navigation. Because of the presence of Niagara Falls, the Niagara River is not a navigable connection. The navigation link between Lakes Erie and Ontario is the Welland Canal, which is entirely located in the Province of Ontario.

Locks are required on two of the four connecting channels - St. Marys River and the Welland Canal. The four locks on the St. Marys River are collectively referred to as Soo Locks. The Welland Canal consists of eight locks with a total vertical drop of 326 feet. The Straits of Mackinac is a natural channel that requires minimal maintenance. The Detroit - St. Clair River System has to be dredged in order to provide a navigable channel.

There also are seven commercial navigation locks on the St. Lawrence River, five of which are operated by the St. Lawrence Seaway Authority of Canada, and the other two by the St. Lawrence Seaway Development Corporation of the United States.

The navigable connecting channels are the major constraints to shipping on the Great Lakes. To pass from one lake to another, a vessel must pass through a minimum of one connecting channel. In traversing the system from Lake Superior into the St. Lawrence River a vessel must pass through the Soo Locks on the St. Marys River, through the Detroit - St. Clair River System, and through the Welland Canal. The dimensions of the locks through which a vessel must pass determines the maximum size vessel that can be used on that particular route. In the above illustration, it is the Welland Canal that determines the size of vessel as the Poe Lock on the St. Marys River is larger than the locks on the Welland Canal.

The water surface elevations (lake levels) of the Great Lakes vary; they vary seasonally and they vary secularly. Variations in lake levels affect commercial navigation on the lakes. The International Joint Commission (IJC) monitors lake levels and, to the extent that is physically possible, regulates Lakes Ontario and Superior. Regulation is more effective on Lake Ontario than Lake Superior but in both cases it is far from complete.

Chapter 4. The Great Lakes Fleet

In 1990 the commercial navigation fleet operating on the Great Lakes numbered 185 vessels of which 117 were of Canadian registry and 68 were of U.S. registry. This compares to 277 vessels in the aggregate fleet in 1973 and 302 in 1980. Between 1980 and 1990 a total of 86 vessels were retired from the U.S. fleet while four new vessels were added; thus the net loss was 82 vessels.

Of the 86 vessels retired from the U.S. fleet in the 1980s, 71 were bulk carriers - vessels which do not contain loading/unloading equipment on board. It was the virtual elimination of bulk carriers which accounted for most of the decline in the American fleet. In 1990 the U.S. fleet dominantly

consisted of self-unloading vessels - vessels that contain loading/unloading equipment on board; 55 of the 68 vessels were self-unloaders.

The U.S. fleet has become smaller but the average size of vessel in the fleet has increased. The principal reason for this has been the retirement of small bulk carriers and the addition of large, self-unloaders. At present all 14 of the large Class 9 and 10 vessels, the largest operating on the lakes, are of American registry. While the size of the U.S. fleet has decreased since 1973, the total per trip carrying capacity of the fleet increased. In 1990 the average carrying capacity of U.S. self-unloaders was about 34,400 tons. The U.S. fleet has become smaller, but it also has become much more efficient.

Vessel size is an important determinant of unit transportation costs. Using the real world example of transportation of iron ore from Duluth to Cleveland, it has been determined that the unit transportation cost for a Class 10 vessel is 20% less than the corresponding transportation cost for a Class 5 Vessel. Over a shipping season the use of the Class 10 vessel could produce a total transportation savings of $4.2 million in transporting 2.8 million tons of ore between the two harbors.

Chapter 5. Commodity Flows

Bulk commodities comprise the great majority of total shipments transported on the Great Lakes. General cargo, also termed package freight, is estimated to account for about three percent of all freight movements on the lakes.

The principal bulk commodities shipped across the lakes are iron ore, coal, grain and limestone. Historically iron ore has ranked first, followed by coal, grain and stone. In the past decade the volume of grain transported on the lakes has declined substantially such that currently stone ranks third and grain ranks fourth.

Iron ore. The shipment of iron ore is the backbone of the commercial navigation industry on the Great lakes. In a non-recessionary year 60 to 70 million tons are shipped across the lakes. Most, about 80%, originates in the iron producing region of northeastern Minnesota and the western portion of the Upper Peninsula of Michigan. The ore is shipped to integrated steel mills in the United States that are situated in Great Lakes industrial centers and also to some nearby inland centers. The leading iron ore shipping harbor is Duluth-Superior, which ships about 20 million tons in a non-recessionary year.

About 20% of the iron ore transported on the lakes originates in eastern Canada. The ore is shipped south by rail to three Canadian harbors on the north shore of the St. Lawrence River. There the ore is loaded into Great Lakes freighters and shipped up the St. Lawrence to Canadian, and some U.S., integrated steel mills located on the shores of the Great Lakes. This flow is tied to the downbound shipment of Canadian grain out of the Great Lakes. As the grain ships would otherwise have to return to the Great Lakes empty, they willingly transport the upbound iron ore at a reduced rate. Currently there is concern in Canada that the recent drastic decline in the volume of grain shipments out of the lakes threatens the continued existence of the upbound flow of iron ore.

The report examines the viability of the Great Lakes steel industry through the year 2000. The industry has been restructured in the early 1980s; it is now significantly smaller than it had been. The principal concern that has been examined is the competition provided by domestic mini-mills, which operate electric arc furnaces charged with scrap. In the past three decades mini-mills have been expanding while the integrated mills have been declining. Competition between the two recently has been exacerbated by the introduction of thin slab casting technology to the mini-mills. With this technology mini-mills are now able to produce plate steel at a cost substantially below that of the integrated mills. Since plate steel is the premium product of the integrated mills, the introduction of thin slab casting is a direct threat to the integrated mills.

The examination of the Great Lakes steel industry concludes that it is probable that from one to five of the 20 integrated mills operating in the Great Lakes Basin in 1990 will not exist in 2000. The probability that one will close is extremely high; the probability declines as the number of mills projected to close increases. As it is likely that any mills closed will be the smallest producers, the impact of such closures upon the demand for iron ore transported across the Great Lakes is likely to be minor. A loss of one million tons of steel production will produce a decline of 1,275,000 tons of iron ore and limestone transported across the lakes.

The possible implementation of new technology in steel production complicates the assessment. New technologies, direct reduction or iron carbide technology, if widely implemented would permit the use of iron ore in electric arc furnaces. This could significantly alter the locational pattern of the steel industry and thus affect the quantity of iron ore transported across the Great Lakes.

Coal. In the past decade the volume of coal transported across the Great Lakes has fluctuated from about 35 to 40 million tons per year. All but 2 to 4 million tons originate in the

United States. Most coal shipped across the Great Lakes originates in the Appalachian states and in the states of the eastern Mid West; such coal is known as Eastern Coal. A second major producing region is the Powder River Basin of Wyoming and Montana; this coal is known as Western Coal.

Eastern Coal has a higher energy content than does Western Coal, but Eastern Coal typically has a higher sulfur content than Western Coal. Because of its higher energy content Eastern Coal has been the preferred fuel for thermal electric generating plants located in the eastern U.S. and central Canada (Province of Ontario). Historically Eastern Coal has predominated on the Great Lakes, but with the passage of time and with increased concerns over air pollution, and with the passage of more stringent airborne emission standards, shipments of Western Coal have substantially increased. In 1990 shipments of Eastern Coal totaled to 23.7 million tons and shipments of Western Coal totaled 15.3 million tons; the latter includes 3.0 tons of Canadian lignite - a low grade coal.

It is difficult to predict the volume of coal that will be transported across the Great Lakes. Though at a sulfur content disadvantage vis-a-vis Western Coal, Eastern Coal has the advantage of higher energy content, and because of its location, lower transportation costs. Eastern Coal, even with its higher sulfur content, could continue to be utilized by thermal electric plants if modern "scrubber" technology were implemented by the electric utilities.

An additional complexity is competition from railroads for all rail transportation of Western Coal to eastern utilities. Presently two thermal electric plants in southeastern Michigan are supplied with Western Coal transported by rail from the Powder River Basin. The railroads are aggressively pursuing the market for transporting Western Coal. While dedicated delivery of western coal by lake vessels to major power plants north of Detroit is assured, power plants south of Detroit are now being competitively serviced with western coal by rail.

<u>Grain</u>. Shipments of grain across the Great Lakes in 1989 and 1990 are only slightly more than half what they were a decade earlier. Shipments of Canadian (2/3 of total) and U.S. grain (1/3 of total) amounted to 15.0 and 15.8 million tons respectively in 1989 and 1990. Barring catastrophic crop failures in traditional grain exporting nations, it would appear that grain shipments will be maintained at about this level unless: 1) there is a successful resolution of the agricultural subsidy problem between the U.S. and the European Economic Community (EEC) or 2) the U.S. provides substantial volumes of grain on a continuing basis to the Soviet Union in their transition to a democratic political system and a free market economy.

Limestone. The volume of limestone (and dolomite) transported across the lakes currently exceeds the volume of grain transported across the lakes. The demand for limestone is very sensitive to economic conditions. The rise of limestone from fourth to third in the list of commodities transported on the lakes is more a result of the decline in grain shipments than an increase in limestone shipments. The very recent trend to mix flux stone (a mixture of limestone and dolomite) with the iron ore at taconite pellet producing plants represents a new market for transportation of limestone on the Great Lakes.

Other Bulk Commodities. In addition to iron ore, coal, grain and limestone, substantial but significantly lesser amounts of three additional bulk commodities are shipped across the Great Lakes; they are cement, potash and petroleum products. Potash is sourced entirely in Canada; it is shipped from Thunder Bay, Ontario to ports in eastern Ontario and to U.S. ports in Southern Lake Michigan and Lake Erie. Cement is shipped from two producing sites in the U.S. and one in Ontario. Petroleum products are mainly shipped from the two dominant petroleum refining centers on the Great Lakes, metropolitan Chicago and Sarnia, Ontario. There is no obvious trend in the pattern of shipments of these commodities; in the 1981-1990 interval shipments have fluctuated from about 17 to 20 million tons per year.

Traffic Forecasts. The report examines recently released (May 1991) revised forecasts of traffic through the Soo Locks; the review is restricted to forecasts at the year 2000. The current forecast substantially reduces the volume of grain and iron ore forecast to pass through the locks in 2000. Similarly, it also significantly reduces the volume of Eastern Coal traffic; the forecasted volume of Western Coal is unchanged. The volume of stone traffic forecasted to pass through the locks has been significantly increased. The overall effect is that little change in total tonnage through the Soo Locks is now expected between 1990 and 2000.

Chapter 6. Harbors

A commercial harbor is defined to be any harbor for which statistics have been published in: Advanced Information, Great Lakes Region Freight Traffic Tables, Calendar Year 1989, published by the Waterborne Commerce Statistics Center, Water Resources Support Center, U.S. Army Corps of Engineers. There are 96 commercial harbors on the Great Lakes in the territorial waters of the United States.

Nineteen of the 96 commercial harbors have been constructed, operated, and maintained by private entities; they are termed private harbors. The remaining 77 harbors have been constructed, operated, and maintained by the Federal government; they are

termed Federal harbors. In 1989 private harbors handled 18.4% (53.1 million tons) of all freight transported to/from commercial harbors on the Great Lakes.

The commercial harbors are ranked in order of the tons of freight handed in 1989. The top three harbors were: (1) Duluth-Superior, 40.8 million tons; (2) Port of Chicago, 23.4 million tons; and, (3) Detroit 20.7 million tons. No other harbor handled more than 15 million tons in 1989.

A cumulative distribution of the proportion of all freight handled at all harbors in 1989 was calculated. The top 10 harbors, all with more than 10.0 million tons, handled 61% of all freight. The top 18 harbors, all with more than 5.0 million tons, handled 83.6% of all freight. The top 33 harbors, all with more than 1.0 million tons, handled 95.9% of the freight.

The 96 commercial harbors have been categorized by depth. Thirty-six have a depth of 20 feet or less; the remaining 60 harbors have a depth in excess of 20 feet. The 36 harbors with depths less than 20 feet transported only 0.7% of all freight handled at all U.S. commercial harbors on the lakes in 1989.

Chapter 7. Operations & Maintenance

Federal expenditures for Operations and Maintenance (O&M) on the Great Lakes have been presented for the 1977-90 period. The data are presented in current dollars and constant 1990 dollar formats. The constant dollar data, which eliminates the inflationary effect, shows that real (constant dollar) O&M expenditures have declined substantially over the period. In 1977-79 expenditures averaged $129.0 million per year; in 1984-86 expenditures averaged $92.6 million per year; in 1988-90 expenditures average $76.3 million per year.

Part of the decline can be explained by the high expenditures for implementation of the Corps of Engineers' confined disposal facility (CDF) program in the late 1970s; part may be explained by temporal variation in major rehabilitation expenditures. These two factors do not, however, fully explain the decline. To the extent that the decline reflects less maintenance, particularly less dredging, it remains a topic of concern.

O&M expenditures on the Great Lakes are expended for recreational as well as commercial navigation. An examination of 1990 data indicates that 96.3% ($61.0 million) was expended on behalf of commercial navigation. Of that amount 63.6% ($38.8) million was spent on commercial harbors; 7.9% ($5.0 million) was spent on associated rivers and channel; the remaining 28.5% ($17.1 million) was spent on the connecting channels.

The average O&M expenditure (constant 1990 dollars) per ton of traffic was calculated for the 1984-89 period for each commercial harbor on the lakes. Care has to be taken in interpreting the data as a different time period might yield significantly different results. For the six year period specified, average O&M expenditures per ton amounted to $.28 (constant 1990 dollars). For that period, most harbors had higher than average expenditures per ton.

The harbor maintenance fee provisions of the Water Resources Development Act (WRDA) of 1986 implemented the concept of user fees to commercial navigation at most U.S. harbors. The Act imposed an ad valorem levy of .04 percent on the value of commercial cargo loaded and unloaded at most U.S. ports. The fee was increased to .125 in Fiscal Year 1991. In 1989 and 1990, $183.1 and $197.5 (current) million was collected nationally. In both years $159 million was disbursed to the Corps of Engineers to cover costs incurred in operating and maintaining the commercial waterways of the nation.

Harbor Maintenance Trust Fund income statements show revenue sources by type of commerce, but do not identify the specific harbors where the tax liability was incurred. Therefore, fund revenues attributable to the Great Lakes can only be estimated.

Chapter 8. Other Topics

Confined Disposal Facilities. A confined disposal facility (CDF) is a dike enclosed area constructed to provide environmentally secure storage for contaminated materials obtained from dredging of harbors and channels. There are 37 CDFs at sites distributed along the Great Lakes. Of these, 16 are closed; they do not accept any more materials. Of the remaining 21, 18 are projected to close by the end of 2000. Only two are projected to operate beyond 2000; one is projected to close in 2001 and the other is projected to close in 2009.

The vast majority of the 37 CDFs on the lakes were constructed under the authorization of PL 91-611, now expired. Under this authorization, the Federal government effectively paid 100% of CDF construction and maintenance costs.

The current legal authority for construction of new CDFs at existing harbors lies in the harbor's authorizing legislation and in the terms of local cooperation contained in that authorization. As project authorization legislation varies from project to project, there currently is no consistent authorization for construction of new CDFs at existing harbors.

The cost of constructing a CDF is considerable; the cost could range from $10 to $40 million. The non-federal share of

that amount could range up to 100%. The effect of high costs and large non-federal share of planning and construction costs has been to curtail the construction of CDFs; effectively, bringing the construction of CDFs on the lakes to a halt.

The need for CDFs is affected by a number of variables including the extent to which polluted sediments are transported into streams and rivers and deposited in channels, the long-term water levels of the lakes, water quality standards, volume of economic activity and a number of other factors. It is clear, however, that the need for CDFs will continue into the 21st century.

The CDF problem on the Great Lakes is becoming critical. Without the availability of CDFs or some other disposal option, contaminated channels and harbors would not be dredged. Suspension of dredging would soon result in shallower navigation channels and reduced vessel navigation drafts, which in turn would be reflected in increased transportation costs. The increased transportation costs would be either passed onto industries consuming the commodities transported across the lakes, or alternatively, railroads would capture an increasing amount of traffic that historically has been transported by waterborne carriers.

The capacity of railroads to transport the affected commodities is limited. Railroads would have to add capacity at substantial costs to transport the additional traffic thereby assuring higher transportation rates. One way or another, suspension of dredging would produce a series of events which eventually would adversely impact the industrial economy of the Great Lakes Region. Since the principal industry that would be affected is the steel industry, which at the national level is concentrated in the region, the effect also would be distributed across the national economy.

Corps of Engineers' Reports and Projects. A number of reports and activities are in progress that will affect the future of the Great Lakes System. With the exception of the rehabilitation of the Welland Canal, these are U.S. Army Corps of Engineers' reports and projects.

The Canadian Federal government is in the final stage of completing a five year, $175 million (Canadian) project to rehabilitate the Welland Canal. The project should enable the Welland to function effectively through 2043.

A Draft Feasibility Report has been completed for the St. Lawrence Seaway Additional Lock Study, N.Y. The report, completed in 1987, recommended termination of the study because of a lack of economic justification and the perception of lack of interest by the Canadian Federal government to implement the project in

the near future. However, the study was given a five year extension in which time the Corps of Engineers is to update the draft feasibility study. The last update is scheduled to be completed in July 1992 at which date the study authority will expire.

A Final Feasibility Report has been completed for the Replacement Lock, Sault St. Marie, Michigan. The report has been forwarded to the Office of the Chief of Engineers. Due to a lack of a local sponsor for the non-federal cost-share, the $268 million project has not been forwarded to the Office of Management and Budget. The non-federal share of the project amounts to $93.8 million or 35% of the total cost.

The Sault St. Marie Lock Operation (Navigation Season Extension), Michigan study has recommended a new navigation operating plan. In response to the recommended plan, a Record of Decision has been signed establishing 15 January as the closing date for the Soo Lock. In addition funds have been authorized to investigate the effects of opening the Soo Lock prior to 1 April.

The Corps of Engineers has a number of harbor/channel projects in various stages of planning and development. These studies include: Great lakes Connecting Channels and Harbors; Grand Haven Harbor, Michigan; Menominee Harbor and River, Michigan and Wisconsin; Saginaw Bay and Saginaw River, Michigan; and the St. Joseph Harbor, Michigan. The potential rehabilitation of the Davis Lock at Sault Ste. Marie, Michigan, pending a decision on construction of a large replacement lock, also would involve a significant amount of engineering and design work.

Chapter 9. Conclusions

The following points are highlighted in characterizing the Great Lakes navigation system:

1. <u>The near term future (to the year 2,000) of the Great Lakes commercial navigation industry is secure.</u> The volume of freight to be transported across the Great Lakes during the remainder of the current decade will fluctuate depending upon national and international economic conditions, but the industry in 2000 should be much the same as that in 1991.

2. <u>The U.S. Great Lakes fleet is modern and efficient.</u> The strength of the fleet lies in the 13 Class 10 vessels, which can carry bulk cargoes long distance on the upper four Great Lakes very economically, as well as the large number of self-unloading vessels of all sizes that can efficiently service Great Lakes ports of varying channel depths and constraints.

3. The Great Lakes navigation system serves the long distance transport of low to medium value bulk materials to greatest advantage. The long term health of the commercial navigation industry and system will continue to depend on the shipments of large volumes of iron ore (taconite pellets), coal, limestone, grain, and petroleum products.

4. Tremendous increases in transportation efficiencies have been achieved in the rail, trucking, and marine industries during the 1980's, including the Great Lakes shipping industry. Large numbers of old lake vessels have been scrapped since 1980, while the average size of cargo shipments has increased greatly. Railroads, however, have become a competitive factor in the delivery of western coal to power plants south of Detroit. Competitive pressures will continue to drive all transportation modes to seek out methods of reducing the overall costs of delivering bulk cargoes.

5. Solutions for disposing of contaminated dredged material from channels and harbors are needed. Much of the capacity of existing Confined Disposal Facilities (CDF's) will be fully utilized by the year 2000. The expiration of the authority to construct CDF's at full Federal expense (Section 123 of PL 91-611) means that new methods of complying with environmental standards and cost sharing requirements must be developed.

6. The level of Federal expenditures for Operation and Maintenance on the Great Lakes has been declining. Annual O&M expenditures in constant dollars have declined sharply in the past 10 to 15 years. Levels have decreased from $129 million per year over the 1977-79 period, to $76.3 million per year in the 1988-90 period.

CHAPTER 1

INTRODUCTION

OBJECTIVE

The objective of this report is to provide a comprehensive overview of the role of the Great Lakes as part of the waterways transportation system of the United States. The Lakes and associated St. Lawrence Seaway are a distinct component of both the nation's waterways system, and the nation's multimodal transportation system. This chapter provides an initial perspective by comparing Lakes transportation with other U.S. waterborne commerce, and transportation by alternate modes.

In 1989, total U.S. waterborne commerce via the Great Lakes was 168.9 million short (2000#) tons. Total tonnage handled by U.S. Great Lakes ports was 277.9 million tons because most of the commerce is both shipped and received within the Lakes. The composition of that commerce is summarized in Table 1.

TABLE 1. U.S. WATERBORNE COMMERCE CARRIED ON THE GREAT LAKES, 1960-1989 (millions of short tons)

Category	1960	1970	1980	1989
Foreign Commerce				
Overseas via Seaway	4.9	11.4	10.0	9.4
Canada via Seaway(1)	6.1	18.9	17.2	9.9
Canada Translake	25.0	32.1	33.4	35.6
Domestic Commerce				
Local, Intraport	4.7	7.0	5.4	3.3
Lakes/Inland WW	2.1	1.7	2.2	1.7
Interlake,Intralake	155.1	157.1	115.1	109.0
Total	197.9	228.2	183.5	168.9

(1) Includes U.S. overseas trade transhipped on the lower St. Lawrence

As shown, direct U.S. overseas trade via the St. Lawrence Seaway represents about five percent of U.S. Great Lakes commerce. It accounts for less than one percent of all U.S. waterborne foreign commerce. Although the overseas Seaway tonnage is relatively stable, the composition of that traffic has changed over time. A multitude of factors affect that traffic, and addressing them fully would consume a disproportionate part of this report.

Therefore, this report focuses primarily on use of the Great Lakes for U.S. domestic commerce, and to a lesser degree, on U.S. trade with Canada including use of the Seaway.

For similar reasons, this report focuses on the ports and waterways infrastructure that is provided and maintained exclusively by the United States through the U.S. Army Corps of Engineers. Specific concerns with respect to that infrastructure, including traffic projections for the Soo Locks and confined dredged material disposal, are addressed in a subsequent chapter. Intervening chapters describe how the Lakes operate as a transportation system.

THE WATERWAYS OF THE UNITED STATES: AN OVERVIEW

The Waterway Transportation System of the United States has three components: the Deep Draft Coastal Ports and Related Waterways, the Shallow Draft Inland and Intracoastal Waterways and the Great Lakes System. The Shallow Draft Inland and Intracoastal Waterway is usually disaggregated into three geographic segments: the Mississippi River System and the Gulf Coast Intracoastal Waterway, the Atlantic Intracoastal Waterway, and the Pacific Coast System.

The three components of the nation's waterway system differ from each other in a number of characteristics. Excluding their geographic locations, the basic differences between them are in the depths of navigable water, the types of vessels and the characteristic draft of the vessel types, the spatial pattern of vessel movements, and the nature of commodities transported through each system. Depth of water and draft of vessels obviously are interrelated. The channel depth must exceed the vessel draft. The distinction in water depth and vessel type and draft between the three U.S. water transportation components are clear and distinct.

The Shallow Draft Inland and Intracoastal Waterway consists of channelized river segments and man made canals with a draft of 14 feet or less. Barges and "towboats" navigate the shallow draft waterways. The term "towboat" is somewhat of a misnomer as towboats do not tow; they push. Towboats push aggregations of barges up and down the channelized rivers and canals of the nation.

The spatial pattern of vessel movement through the shallow draft system is necessarily highly constrained and confined; the vessels proceed up and down the system in a linear manner. The channels are narrow and because of the inherent low maneuverability of a "tow", there is no possibility for unconstrained movement.

Barges are well suited to transport large volumes of bulky, low valued commodities. Such commodities cannot bear high unit transportation costs if they are to be moved substantial distances. Barges thus tend to transport primary products - agricultural commodities and various mineral commodities, where cost considerations are more important than speed of delivery. They are most effective in providing transportation over substantial distances, generally in excess of several hundred miles. For shorter distances the cost of loading and unloading the barge tends to offset the savings in line-haul costs that barges provide.

Ships, some of which are very large with drafts in excess of 40 feet, navigate the Deep Draft Coastal Ports and Related Waterways. While there are numerous smaller freighters, many drafting less than 27 feet, the principal character of this fleet is that it consists of large vessels capable of carrying very large quantities of commodities great distances at very low costs.

The spatial pattern of vessel movement through the deep draft system is largely unconstrained and unconfined. The vessels characteristically navigate the oceans and they may proceed from any one port to another, as long as the necessary draft constraint is met. Of course, as the vessels enter a port they are constrained, but in general they are free to navigate the open seas as they deem appropriate. This is in marked contrast to the rigidly constrained and confined linear flows along the rivers and canals of the shallow draft system.

Ships navigate the Great Lakes System and, although some are larger than many-ocean going vessels, the general size and draft of the Great Lakes fleet is less than that of the oceanic fleet. The size and draft of vessels navigating on the Great Lakes is restricted by the physical dimension of locks through which the ships must pass, if any, and the depths of water provided in harbors and in connecting channels that link the lakes.

Movement across the Great Lakes is not nearly as constrained nor as confined as vessel movement through the shallow draft system, but it is more constrained and confined than vessel movement through the deep draft system. Perhaps the best term to describe the spatial pattern of vessel movement across the Great Lakes is that it is "quasi-confined". A vessel may proceed in any direction across the open waters of one, or at the most of two interconnected lakes, but if it intends to move through more than the one or two lakes it must pass through one or more connecting channels that link the lakes into a physical system.

Ships navigating the deep draft system and the Great Lakes tend to transport a combination of low valued, high bulk, primary commodities and higher valued per unit weight finished goods - manufactured products. Deep draft ocean going vessels transport

most of the primary and manufactured products entering into international trade. Increasingly the two categories of commodities are shipped in different vessels. Manufactured products with their high value per unit weight and the need for rapid, secure shipment tend to be shipped in containers which are loaded upon specially constructed container ships. Primary commodities tend to be transported in conventional ships.

Only a very small proportion of manufactured goods produced in Great Lakes industrial centers are shipped on the Great Lakes. The principal reasons are that such goods can be shipped more efficiently by land transportation modes - railroads and trucks. Additionally the Great Lakes have been unable to compete with East Coast ports for the container trade. The principal reasons for the latter are the increased efficiency of the railroads in transporting containers to East Coast ports and the economies of scale available at those ports from the large volume of containers they process. As a result the vast majority of goods transported on the Great Lakes are primary commodities. Since they are generally shipped without packaging, the latter are more generally referred to as bulk commodities.

The shallow draft system serves the southern and western portion of the Great Lakes Region by means of the Mississippi River and its tributary, the Illinois Waterway. Because the two systems transport similar commodities, and because to some extent they both serve the Great Lakes Region, there is substantial competition between the two systems. However by far the most effective competition to the water transportation on both systems is the competition provided by the three principal modes of land transportation -- truck, rail and pipelines.

COMPETITION BETWEEN TRANSPORTATION MODES

The nature of transportation services utilized by the U.S. economy has changed substantially since World War II. The quantity of freight shipped has grown and the mix of freight shipments by modes has been significantly altered. There is a debate in the literature of transportation economics as to whether change in transportation technology has been the cause or whether transportation technology has been the beneficiary of change in the structure of the nation's output. Be that as it may, the amount of inter-city freight shipped has grown and the pattern of modes has been altered. Table 2 and Figure 1 displays data on shipments of inter-city freight by mode for the period 1947-1990.

Total freight shipments have grown appreciably in the past 44 years: from 2.9 billion tons in 1947 to 6.4 billion tons in 1990. Most noticeable is that the volume of intercity freight shipped by railroads has not grown much; intercity movements of freight via railroads in 1990 were only slightly above their 1947

TABLE 2. DOMESTIC INTERCITY FREIGHT BY MODE, 1947-1990
(Millions of Tons)

Year	Rail	Truck	Oil Pipeline	Water	Air	Total
1947	1613	556	238	466	0.2	2873.2
1948	1580	572	262	516	0.2	2930.2
1949	1284	630	261	473	0.3	2648.3
1950	1421	794	284	544	0.4	3043.4
1951	1547	871	325	578	0.3	3321.3
1952	1447	913	338	555	0.4	3253.4
1953	1448	1007	359	603	0.4	3417.4
1954	1279	1033	373	549	0.4	3234.4
1955	1459	1063	413	631	0.5	3566.5
1956	1521	1223	441	650	0.5	3835.5
1957	1449	1113	441	659	0.5	3662.5
1958	1247	1122	433	587	0.5	3389.5
1959	1293	1156	464	619	0.6	3532.6
1960	1301	1181	468	655	0.6	3605.6
1961	1253	1323	484	638	0.8	3698.8
1962	1294	1421	502	667	0.9	3884.9
1963	1347	1507	521	788	1.0	4164.0
1964	1420	1670	559	715	1.2	4365.2
1965	1479	1641	588	726	1.4	4435.4
1966	1543	1744	630	762	1.7	4680.7
1967	1498	1845	679	768	1.9	4791.9
1968	1515	1811	726	795	2.4	3849.4
1969	1558	1768	760	839	2.6	4927.6
1970	1572	1828	790	867	2.9	5059.9
1971	1472	1862	807	863	2.9	5006.9
1972	1531	1934	876	895	3.3	5239.3
1973	1616	2028	912	897	3.5	5456.5
1974	1619	2035	885	890	3.5	5432.5
1975	1471	1744	879	856	3.2	4953.2
1976	1477	1974	934	892	3.4	5280.4
1977	1467	2143	986	886	3.6	5485.6
1978	1481	2260	982	983	3.9	5709.9
1979	1600	2240	979	984	3.7	5806.7
1980	1589	2007	921	980	4.6	5501.6
1981	1547	1964	886	958	4.1	5359.1
1982	1351	1791	897	878	4.2	4921.2
1983	1377	1916	899	880	4.7	5076.7
1984	1522	2125	917	949	5.4	5518.4
1985	1439	2139	918	937	5.8	5438.8
1986	1436	2211	955	955	6.3	5563.3
1987	1523	2326	960	990	6.8	5805.8
1988	1601	2446	991	1023	7.3	6068.3
1989	1612	2543	1053	1017	7.3	6232.3
1990	1694	2598	1041	1028	7.5	6368.5

Source: Transportation in America, Ninth Edition, May 1991.

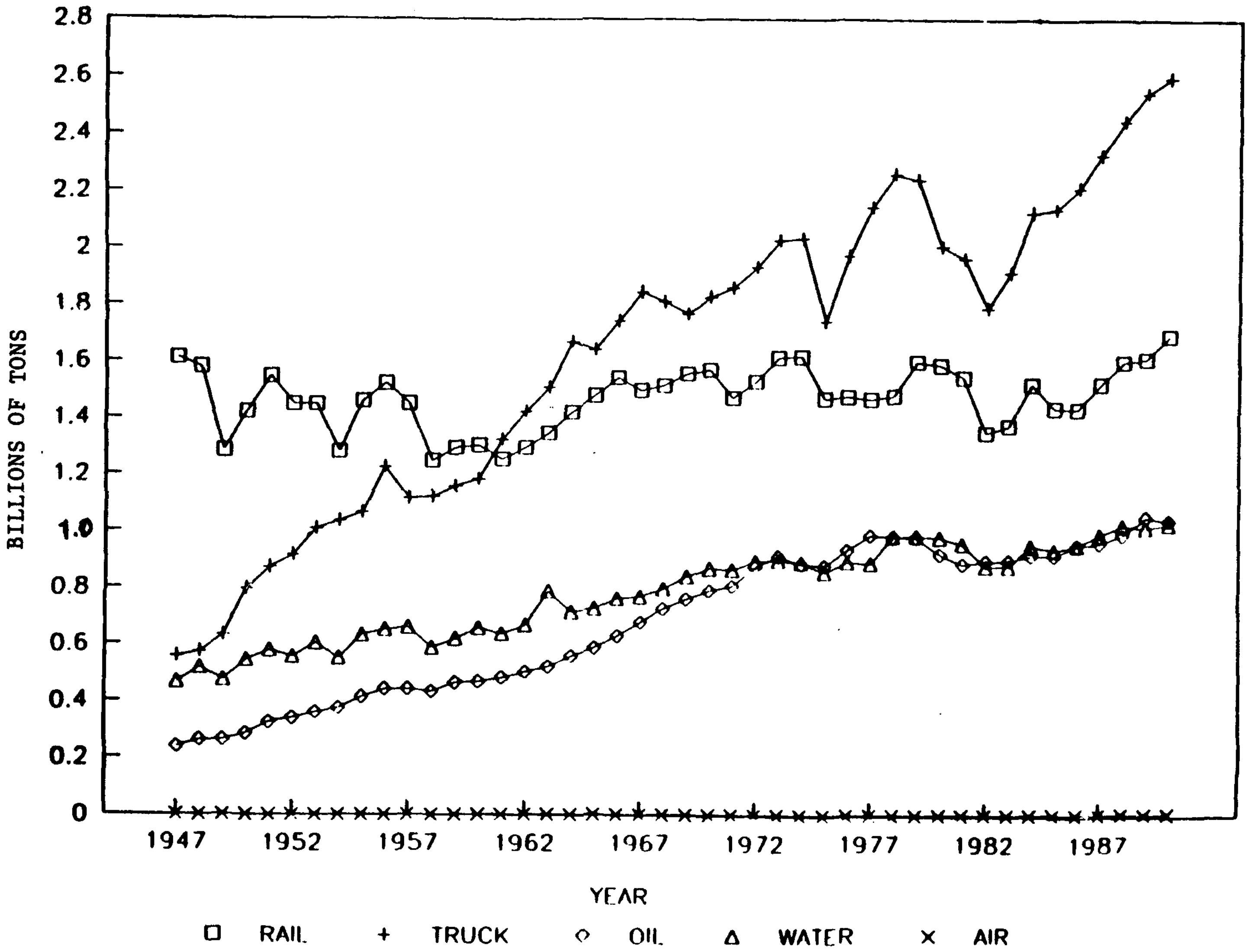


FIGURE 1. DOMESTIC INTERCITY FREIGHT BY MODE, 1947-1990

level. In general intercity shipments of freight over railroads declined from 1947 to 1958, when it bottomed out, and grew from 1959 to 1974. Since 1974 railroad shipments of intercity freight have fluctuated at around the 1974 level. In the 1974 - 1990 period, 1990 was the only year in which tonnage exceeded the 1974 volume.

The growth of intercity freight movements came from three modes: truck, oil pipelines and water. Trucks have accounted for most of the growth; 2.0 billion more tons were shipped via trucks in 1990 than in 1947. The growth for oil pipelines, 803 million tons, exceeded that for water, about 562 million tons. Air freight, which grew substantially between 1947 and 1990, was and still remains a minor carrier of intercity freight. It has experienced steady growth in the 1947-1990 period.

One way to view the change in the composition of transportation services is to examine the data on the percent distribution of intercity freight movements by mode for the 1947 to 1990 period. The change is very pronounced (Table 3). Railroads, which in 1947 transported 56% of all intercity freight shipments, transported only 26.6 % in 1990. Trucks, which are the principal competitor to railroads for intercity freight shipments, have experienced the most significant growth in market share; from 19.4% in 1947 to 40.8% in 1990. The principal reason for the growth of trucking and the decline of the railroads has been the ability of the former to provide superior quality (fast and reliable) transportation services.

The share of intercity freight transported by pipelines grew reasonably consistently from 8.3% in 1947 to 18.0% in 1977 and has tended to fluctuate at somewhat lower levels since then. Since 1982 its share has been declining. Presumably this decline reflects decreasing U.S. petroleum production and increased petroleum imports. In 1990 oil pipelines accounted for 16.4% of all domestic intercity movements of freight.

Water's share of intercity freight shipments grew modestly between 1947 (16.2%) through 1960 (18.2%). Notice that it attained its peak share in 1968, significantly earlier than did trucks (1989) and oil pipelines (1977). Since 1969 its share has fluctuated at the 16 - 17% level. Its 1990 share (16.1%) was 0.1% less than its share in 1947 (16.2%).

The data for water transportation of intercity freight includes data for shipments on the Great Lakes, for shipments through rivers and canals, and for coastwise shipments exclusive of the Great Lakes. Table 4 presents this data along with the Great Lakes' share of all water intercity freight shipments. Figure 2 graphs the data presented in Table 4.

TABLE 3. PERCENT DISTRIBUTION OF DOMESTIC INTERCITY TONNAGE BY YEAR AND BY MODE, 1947-1990

Year	Rail	Truck	Oil Pipeline	Water	Air	Total
1947	56.1	19.4	8.3	16.2	0.0	100.0
1948	53.9	19.5	8.9	17.6	0.0	100.0
1949	48.5	23.8	9.9	17.9	0.0	100.0
1950	46.7	26.1	9.3	17.9	0.0	100.0
1951	46.6	26.2	9.8	17.4	0.0	100.0
1952	44.5	28.1	10.4	17.1	0.0	100.0
1953	42.4	29.5	10.5	17.6	0.0	100.0
1954	39.5	31.9	11.5	17.0	0.0	100.0
1955	40.9	29.8	11.6	17.7	0.0	100.0
1956	39.7	31.9	11.5	16.9	0.0	100.0
1957	39.6	30.4	12.0	18.0	0.0	100.0
1958	36.8	33.1	12.8	17.3	0.0	100.0
1959	36.6	32.7	13.1	17.5	0.0	100.0
1960	36.1	32.8	13.0	18.2	0.0	100.0
1961	33.9	35.8	13.1	17.2	0.0	100.0
1962	33.3	36.6	12.9	17.2	0.0	100.0
1963	32.3	36.2	12.5	18.9	0.0	100.0
1964	32.5	38.3	12.8	16.4	0.0	100.0
1965	33.3	37.0	13.3	16.4	0.0	100.0
1966	33.0	37.3	13.5	16.3	0.0	100.0
1967	31.3	38.5	14.2	16.0	0.0	100.0
1968	39.4	21.1	18.9	20.7	0.1	100.0
1969	31.6	35.9	15.4	17.0	0.1	100.0
1970	31.1	36.1	15.6	17.1	0.1	100.0
1971	29.4	37.2	16.1	17.2	0.1	100.0
1972	29.2	36.9	16.7	17.1	0.1	100.0
1973	29.6	37.2	16.7	16.4	0.1	100.0
1974	29.8	37.5	16.3	16.4	0.1	100.0
1975	29.7	35.2	17.7	17.3	0.1	100.0
1976	28.0	37.4	17.7	16.9	0.1	100.0
1977	26.7	39.1	18.0	16.2	0.1	100.0
1978	25.9	39.6	17.2	17.2	0.1	100.0
1979	27.6	38.6	16.9	16.9	0.1	100.0
1980	28.9	36.5	16.7	17.8	0.1	100.0
1981	28.9	36.6	16.5	17.9	0.1	100.0
1982	27.5	36.4	18.2	17.8	0.1	100.0
1983	27.1	37.7	17.7	17.3	0.1	100.0
1984	27.6	38.5	16.6	17.2	0.1	100.0
1985	26.5	39.3	16.9	17.2	0.1	100.0
1986	25.8	39.7	17.2	17.2	0.1	100.0
1987	26.2	40.1	16.5	17.1	0.1	100.0
1988	26.4	40.3	16.3	16.9	0.1	100.0
1989	25.9	40.8	16.9	16.3	0.1	100.0
1990	26.6	40.8	16.4	16.1	0.1	100.0

Source: Transportation in America, Ninth Edition, May 1991.

TABLE 4. DOMESTIC INTERCITY FREIGHT BY WATERWAYS, 1947-1990
(Million of Tons)

Year	Great Lakes	Rivers & Canals	Coastal	Total	Great Lakes as Percent of Total
1947	163	150	163	466	35.0
1948	172	170	174	516	33.3
1949	146	166	161	473	30.9
1950	170	191	183	544	31.3
1951	178	213	187	578	30.8
1952	154	217	184	555	27.7
1953	189	225	189	603	31.3
1954	145	217	187	549	26.4
1955	185	250	196	631	29.3
1956	174	270	206	650	26.8
1957	182	281	196	659	27.6
1958	132	261	194	587	22.5
1959	131	282	206	619	21.2
1960	155	291	209	655	23.7
1961	137	294	207	638	21.5
1962	136	316	215	667	20.4
1963	142	332	314	788	18.0
1964	151	358	206	715	21.1
1965	154	370	202	726	21.2
1966	164	390	208	762	21.5
1967	154	399	215	768	20.1
1968	151	430	214	795	19.0
1969	161	461	217	839	19.2
1970	157	472	238	867	18.1
1971	141	479	243	863	16.3
1972	145	507	243	895	16.2
1973	157	503	237	897	17.5
1974	146	511	233	890	16.4
1975	120	504	232	856	14.0
1976	132	524	236	892	14.8
1977	109	529	248	886	12.3
1978	143	535	305	983	14.5
1979	144	535	305	984	14.6
1980	115	535	330	980	11.7
1981	115	521	322	958	12.0
1982	72	495	311	878	8.2
1983	83	487	310	880	9.4
1984	98	543	308	949	10.3
1985	92	535	310	937	9.8
1986	87	560	308	955	9.1
1987	96	570	324	990	9.7
1988	110	588	325	1023	10.8
1989	109	606	302	1017	10.7
1990	108	627	293	1028	10.5

Source: Transportation in America, Ninth Edition, May 1991.

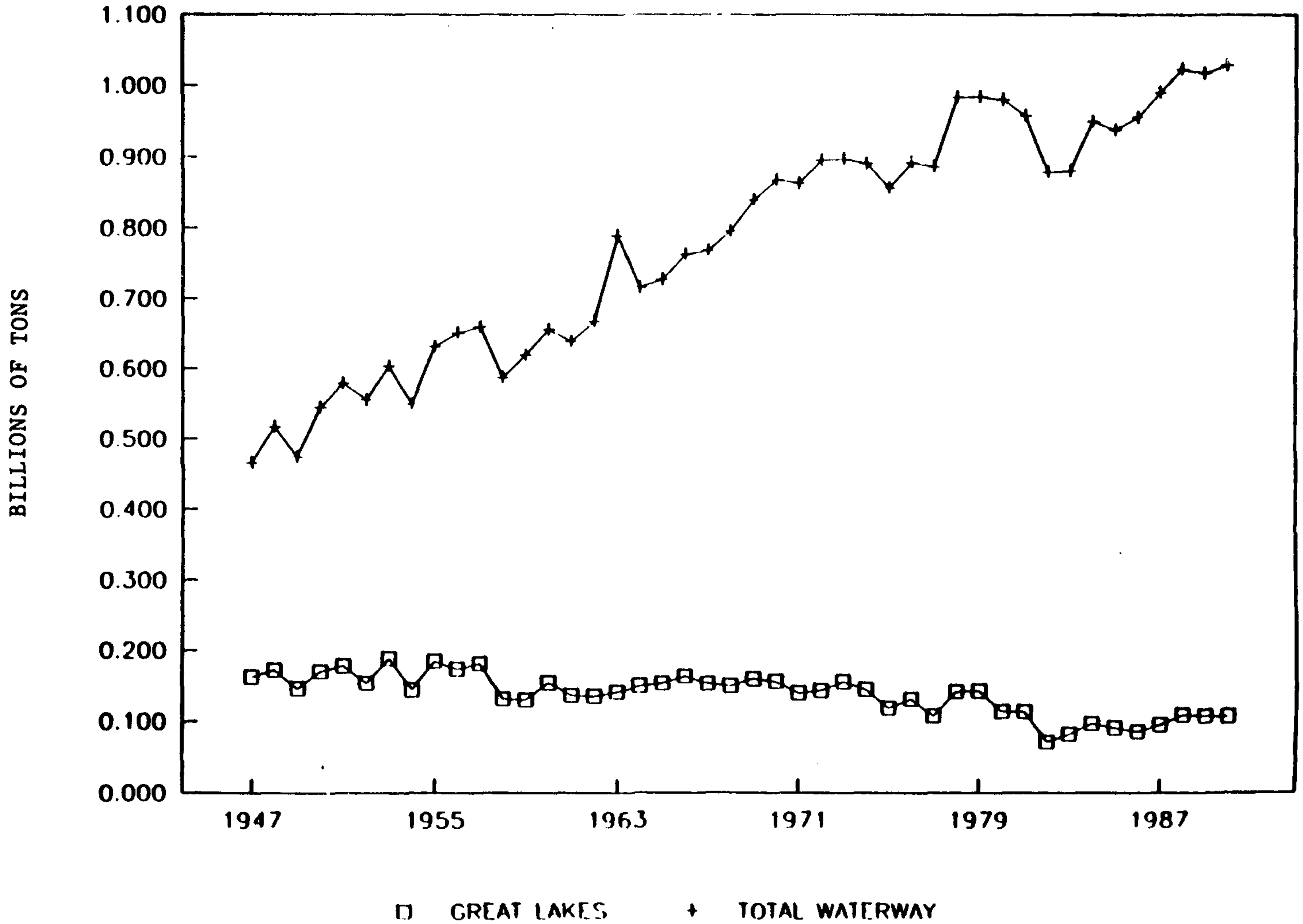


FIGURE 2. GREAT LAKES AND TOTAL WATERWAYS INTERCITY FREIGHT, 1947-1990

The volume of intercity freight traffic on the Great Lakes within the United States has diminished, both in absolute and relative terms. Whereas 163 million tons of U.S. freight were transported via the Great Lakes in 1947, the corresponding figure for 1990 was 108 million tons (Table 4). As a percentage of total domestic intercity freight the Great Lakes' share has declined substantially, from 35.0% in 1947 to 10.5% in 1990. The decline in share was persistent through 1982 when it attained the minimum of 8.2%. Since 1982 the Great Lakes' share has rebounded somewhat and has fluctuated around the 10% figure. Though this data refers to domestic U.S. shipments and it excludes Canadian shipments on the lakes, the inclusion of the latter data would probably not change the overall picture.

ORGANIZATION OF THE REPORT

This report is organized into nine chapters; this introduction is Chapter 1. Chapter 2 presents a historical and institutional perspective of the industry. It provides a very brief history of commercial navigation on the lakes and a discussion of the principal institutions that affect commercial navigation on the lakes. Though emphasis is upon American institutions, consideration is given to the international aspect of the Great Lakes.

Chapter 3 presents an overview of the geography of the lakes. After briefly discussing the regions affected by commercial navigation on the lakes, it discusses the geography of the Great Lakes and their connecting channels. Related topics of lake levels and lake level regulation are also discussed.

Chapter 4 discusses the composition of the Great lakes fleet, both U.S. and Canadian. Particular attention is paid to recent changes in the composition of the fleet by vessel type and size. The chapter ends with a discussion of the significance of vessel size to waterborne transportation costs.

Commodity flows are addressed in Chapter 5. The spatial flows of the principal bulk commodities transported across the lakes are discussed. The commodities discussed include iron ore, coal, limestone, grain and "other" bulk commodities. Because of the importance of iron ore to commercial navigation on the lakes, and because the iron ore is consumed by the steel mills situated along the shores of the lakes and in nearby inland locations, the chapter includes a discussion of the viability of the steel industry in the Great Lakes Basin. The chapter concludes with an examination of a recent set of forecasts of commercial navigation traffic through the Soo Locks for the year 2000.

Chapter 6 provides a discussion of U.S. harbors on the Great Lakes. Data on tonnages transported at each commercial harbor are provided for the years 1984-1989. The composition of harbors organized by commodities transported and the categorization of harbors by depth are examined. Harbors are ranked by the volume of traffic in 1989 and a rank order of the U.S. harbors is presented. The three most prominent ports on the U.S. side of the lakes -- Duluth-Superior, Chicago and Detroit are briefly addressed.

United States Federal expenditures for maintenance of the Great Lakes are discussed in Chapter 7. Data are presented on the disposition of Federal maintenance funds by lake and harbor. Data on maintenance expenditures per ton of cargo are presented for the harbors on the lakes. The chapter ends with a discussion of the Harbor Maintenance Fee, which presently funds most operation and maintenance of commercial navigation facilities and channels in the Great Lakes.

Chapter 8 briefly summarizes recent and potential future improvements to the Great Lakes, including confined disposal facilities, and other construction and studies.

Chapter 9 presents some preliminary conclusions about the commercial navigation industry on the Great Lakes.

CHAPTER 2

HISTORICAL AND INSTITUTIONAL PERSPECTIVE

Commercial navigation is intimately intertwined with the historical and economic development of the interior of the North American Continent. Since the commercial navigation industry is only one of several major users of the Great Lakes, it must share an environment that is affected by numerous public, private and quasi-public agencies. This chapter addresses both of these topics.

HISTORICAL PERSPECTIVE

Commercial navigation on the Great Lakes was first reported in 1678 when La Salle built a small, 10 ton sailing vessel to transport supplies from what is now Kingston, Ontario to a site on the Niagara River. The cargo was a load of grain obtained by trade with Seneca Indians. In 1679, La Salle built a larger ship, the Griffon, with which he sailed the full length of Lake Huron, through the Straits of Mackinac and down Lake Michigan to Green Bay.

The first wave of major commercial navigation upon the lakes began with the opening of the Northwest Territory in 1787. By the early 1800s about two dozen communities had been established along the shores of Lakes Ontario and Erie, and on the St. Lawrence River. Grain and furs were the basic commodities transported out of the region. In 1797 the first of a series of locks that eventually culminated in the Soo Locks was constructed on the Canadian side of the St. Marys River, the connection between Lakes Superior and Huron. This made the entire Great Lakes navigable to canoes and bateaux of the fur trade.

The opening of the Erie Canal in 1825, connecting the Hudson River with Lake Erie, initiated the second stage of commercial navigation on the lakes. The canal's four foot depth and 40 foot width enabled mule drawn canal boats to transport as much as 30 tons of freight. The opening of the Erie Canal initiated the commercial grain trade on the lakes. With much less expensive water transportation across New York State, it was possible for grain grown as far west as Illinois to be efficiently transported to eastern markets. Chicago, with its proximity to the fertile, productive soils of the tall-grass prairie of central Illinois, became the leading grain shipping port on the lakes. Buffalo became the major grain receiving port and eventually the world's largest grain milling center.

Until the opening of the first Welland Canal across the Niagara Peninsula of southern Ontario in 1829, commercial navigation across the lakes was restricted to the Great Lakes

Basin. With the exception of the Erie Canal, there was no access to the Atlantic Ocean because of the presence of Niagara Falls on the Niagara River and a series of falls and rapids on the St. Lawrence River. Once the Welland Canal opened, vessels originating on the Great Lakes could proceed into Lake Ontario and then into the St. Lawrence River. By 1850 a nine foot channel had been established from the Atlantic Ocean to Lake Ontario. By that date the second Welland Canal had been completed (in 1844) and all but Lake Superior was accessible to commercial navigation by ships.

Construction of a canal to bypass the falls on the St. Marys River between Lakes Huron and Superior had to await the need for commercial access to Lake Superior. That need developed with the discovery in 1844 and subsequent development of substantial iron ore deposits in the Upper Peninsula of Michigan. By 1855, a canal had been built to bypass the St. Marys Falls, and Lake Superior became accessible to commercial navigation. A nine foot channel was available from the Atlantic Ocean to the "Head of the Lakes" (western end of Lake Superior).

Water did not have a monopoly on transportation in the Great Lakes Basin for very long. By the 1840s railroads had become relatively efficient and they began to expand into the Great Lakes Basin. This initiated a period of railroad expansion that was to extend the railroad network across the basin. The port at Rochester, N.Y. on Lake Ontario was connected to the Hudson River at Albany, N.Y. in 1841. Toledo, Ohio on Lake Erie was connected to the Ohio River in 1848. Chicago was connected eastward in 1852 and to the west by 1854.

The Canadian cities of Montreal and Toronto were connected by rail in 1856. Construction of the Canadian Pacific Railway (the first transcontinental railway in Canada) began at Port Arthur (Thunder Bay, Ontario) in 1884 and proceeded westward. The establishment of that rail line opened the Canadian Prairie and began the movement of grain by rail from the prairies to Port Arthur for shipment down the lakes.

By 1905, largely as a result of Canadian investment in canals, a 14 foot channel was available from the Atlantic Ocean into Lake Superior. This marked the reemergence of water transportation across the lakes and brought to an end the dominance of rail transportation established a half century earlier. Now, relatively large (for the time) freighters could move bulk commodities across the basin cheaper than could rail.

Probably the most important single construction project affecting commercial navigation on the Great Lakes was the construction of the new Welland Canal in 1932. Its design was farsighted in that it was designed to pass vessels larger than existed on the Great Lakes at that time. It was not until the completion of the St. Lawrence Seaway in 1959, more than a

quarter century after completion of the new Welland Canal, that vessels as long as 730 feet, as broad as 75 feet, drafting as much as 25 feet, began to appear on the lakes. These are "Seaway Size Vessels," capable of carrying 25,000 tons or more of cargo per trip.

INSTITUTIONAL PERSPECTIVE

A number of different government agencies and private enterprises participate in the operation and management of the commercial waterway system on the Great Lakes. The purpose of this section is to discuss their areas of interest and jurisdiction.

The combination of public and private entities that provide waterway transportation has some parallel in the U.S. highway and airway systems. In all three modes Federal participation is derived from the commerce clause of the Constitution.

The Federal interest in waterborne commerce has been established by tradition from the earliest days of the Nation; by legislation, beginning in 1824 with the General Survey Act and the first Rivers and Harbors Act; and by court decisions defining the Federal power to regulate commerce.

The International Level

The Great Lakes are an international water body shared by Canada and the United States. Most commercial navigation projects implemented by the U.S. government are entirely within the territorial limits of the U.S. and are only subject to U.S. jurisdiction. However any project, whether new or a modification to an existing project, that has a systematic effect on water levels and flows on the lakes must be coordinated with and agreed upon by the agency established by the two countries for that purpose. Thus decisions, which for most inland waterways are made at the Federal level in the United States, on the Great Lakes also may have to be considered at the International Level. Additionally, the Federal Government of each country has to interact with its constituents -- states and provinces.

The International Joint Commission (IJC) has been established by the U.S. and Canadian governments to address boundary disputes and to regulate the Great Lakes. Historically, the principal area of concern of the IJC has been regulation of water volumes and levels in the lakes. This will be discussed in more detail in the discussion of lake regulation presented in the Chapter 3, The Geography of the Great Lakes.

Federal Government

The U.S. Federal agencies most directly involved in development and operation of the waterways system are the U.S. Army Corps of Engineers and the U.S. Department of Transportation. The responsibilities of both agencies within the waterways system are part of their broader jurisdictions that include maritime as well as inland waterway transportation. The basic responsibility of the Army Corps of Engineers is to facilitate the movement of vessels. It does so by deepening, widening and straightening channels, by regulating river water levels with dams, and by providing associated locks. As part of its broader jurisdiction the Corps evaluates plans and constructs improvements to inland harbors and channels.

The U.S. Department of Transportation through the Coast Guard has responsibility for vessel and navigation safety, and provides navigation aids and search and rescue services. The Maritime Administration in the Department of Transportation promotes the development and efficient operation of port facilities and waterway vessels.

A recent change in the procedure established to maintain the commercial navigation infrastructure in the deep water harbors and the Great Lakes system has been the implementation of the harbor maintenance fee. A Harbor Maintenance Trust Fund is supported by an ad valorem levy on the value of shipments transported to and from Federally maintained harbors and through Federally maintained channels. The harbor maintenance fee applies to most deep water Federal ports and waterways, including those on the Great Lakes. Funds collected from user fees (the ad valorem levy) are paid into the trust fund and subsequently distributed to the Corps to pay for harbor and channel maintenance. Implementation of the Harbor Maintenance Trust Fund has not affected maintenance of Federal harbors and channels on the Great Lakes and the Corps of Engineers continues to maintain the infrastructure essentially as it has in the past.

The U.S. Environmental Protection Agency (EPA) indirectly affects commercial navigation upon the lakes through its charge to manage water quality. Management of water quality affects commercial navigation in the disposal of materials that are removed from channels by the Corps of Engineers. The individual states and the EPA share responsibility for establishing and implementing standards that specify the method of disposal for dredged materials. The Corps of Engineers must meet these standards. If there is a disagreement between the state, Corps and/or EPA, the EPA has the final say.

The U.S. Saint Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority of Canada constructed the St. Lawrence Seaway and have jointly operated and maintained the waterway since it opening in 1959. The two agencies are

binational partners. The St. Lawrence Seaway Development Corporation is a wholly-government owned corporation and is an operating administration of the U.S. Department of Transportation. The Seaway Authority of Canada is a crown corporation that was created by parliamentary legislation in 1951.

The two agencies operate the Seaway's locks and channels and furnish vessels sailing the Seaway with vessel traffic control assistance. They jointly publish transit regulations for vessels, negotiate and establish the level of Seaway tolls, and set the Seaway's annual opening and closing dates. Additionally, the two agencies participate in the St. Lawrence River Board of Control, an adjunct of the International Joint Commission.

State and Local Governments

Historically the role of state and local governments in the Great Lakes system has been to promote the development of waterways and of their individual ports because of the importance of both to regional and local economic development. This remains a principal function of state and local governments. The establishment of water quality standards for the disposal of dredged materials is a recently acquired, rather important state prerogative.

Direct state investment on the Great Lakes has been limited. Most of the states have encouraged development with enabling legislation for local port authorities. The local authorities are modeled on the authorities in maritime ports, and most non-private investments in commercial navigation facilities on the lakes have been through these local authorities.

The Water Resources Development Act of 1986 (WRDA-1986) has changed the traditional role of the states and local authorities because of its requirements for cost sharing of studies and construction of commercial navigation improvement projects. WRDA-1986 requires that a local sponsor pay a portion of the cost of harbor improvements. The percentage is determined by the project's depth. In the case of an improvement for changes greater than 20 feet, the local sponsor would be responsible for 35% of the construction costs.

Private Enterprises

Participation in the waterways system by government and the private sector is determined by the limits of Federal interest. All of the waterway vessels and cargo terminal facilities needed to produce a useful system are a non-Federal responsibility. All of the vessels are owned and operated by private enterprises. Terminal facilities are predominantly provided by local private

enterprises. Frequently local governments are involved in owning and operating facilities at Great Lakes Harbors. The Great Lakes may be unique in that a significant number of harbors are entirely owned and operated by private agencies.

The ability of private enterprise to provide an adequate supply of terminals and vessels for the waterway system was a matter of concern in the distant past. This is not the case today. The expansion of vessel fleets and port facilities, and their replacement to improve efficiency, are driven by profit opportunity and competitive necessity. As a result, the fleet has expanded and contracted in accordance with the demand for water transportation on the lakes. Within recent times the private sector has been able to provide an adequate supply and has been able to adapt to the need for a changing mix of vessels. The changing nature of the U.S. Great Lakes fleet is discussed in Chapter 4.

Other Agencies

Several other agencies that have an interest in factors that affect commercial navigation on the lakes. Two such agencies are the Lake Carriers Association and the Great Lakes Commission.

The Lake Carriers Association (LCA) was founded in 1880 to represent companies operating U.S. flag freighters on the Great Lakes. Headquartered in Cleveland the LCA has 14 member fleets with a combined roster of 60 vessels. The LCA registered vessels account for about 98 percent of tonnage transported by U.S. vessels on the lakes.

The LCA promotes the common interest of its members with special emphasis on legislative and regulatory matters. Since its founding the association has worked toward enhancing the safety of the maritime environment, supported the environmental quality of the lakes while maintaining the need for commercial navigation on the lakes, supported Federal maintenance of harbors and channels, and aided in the training of maritime personnel. It also maintains a detailed statistical base of movements of bulk commodities across the lakes.

The Great Lakes Commission is an eight state compact agency that guides, protects and advances the common interests of its constituent states in areas of regional environmental quality, resource management and economic development. Established in 1955 by the Great Lakes Basin Commission, it was authorized as an interstate compact commission by the U.S. Congress in 1968. The Commission is comprised of state officials, legislators and governors' appointees. The Commission provides a common regional voice for the states on Great Lakes issues, primarily to the U.S. Congress and to the executive branch.

When the Commission identifies common issues requiring detailed examination, it forms specific task forces of experts from states, private industry and educational institutions. Its research, policy and advocacy activities have addressed issues relating to the economy of the region, environmental quality of the lakes and the quality of life afforded to the residents of the region.

CHAPTER 3

THE GEOGRAPHY OF THE GREAT LAKES

To understand commercial navigation on the Great Lakes one needs to understand the geography of the Great Lakes Region. The reason for this is that commercial navigation on the lakes affects an extensive middle portion of the North American continent.

This chapter addresses the regional and physical geography of the Great Lakes. After defining the area affected by commercial navigation on the lakes, it focuses upon the physical geography of the lakes and their connecting channels. It then addresses the two related topics of fluctuating lake levels and lake regulation.

REGIONS OF THE GREAT LAKES

Geographers generally define a region to be a contiguous domain of geographic space that is relatively homogeneous in one or more attributes compared to areas outside the region. The problem is to: (1) identify the unifying attribute(s); and (2) identify the borders that delineate the spatial extent of the region.

The Great Lakes Region

The unifying attribute of the Great Lakes Region examined in this report is the use of the lakes as a route for commercial navigation. Therefore, the Great Lakes Region is basically an economic region whose boundaries extend as far into the continent as needed to encompass the place of origin of major commodities transported on the Great Lakes.

The principal commodities transported on the Great Lakes are iron ore, coal, limestone and grain. Thus for purposes of this report, the Great Lakes Region is defined to include all states and Canadian provinces extending inland from the shore of the lakes and St. Lawrence River as far inland as necessary to encompass the principal sources of these commodities.

Iron ore is primarily mined at the head of the Lakes in the Arrowhead region of northeastern Minnesota. Lesser but substantial amounts of iron ore are mined in eastern Canada in the vicinity of the Quebec-Labrador boundary. Coal is principally mined in two regions -- the Appalachian and adjacent lower Midwest States in the eastern U.S. and the High Plains states of Wyoming and Montana in the West. Limestone is principally mined

in the northern part of Michigan's Lower Peninsula and the eastern tip of Michigan's Upper Peninsula. Grain (wheat, corn, soybeans and others) is produced extensively across the American Midwest and also on the Great Plains of the U.S. and Canada. Though not a major commodity, potash is produced in the prairie province of Saskatchewan.

Thus defined, the Great Lakes Region extends from Quebec in the northeast, to Saskatchewan in the northwest, to Wyoming in the west, Illinois and Iowa in the southwest and West Virginia in the southeast.

The Great Lakes Basin

The Great Lakes - St. Lawrence River Basin is a subset of the Great Lakes Region. Whereas the latter is an economic region, the former is a natural region, based upon the hydrology of the two waterways. The Great Lakes - St. Lawrence River Basin consists of two subunits -- the Great Lakes Basin and the St. Lawrence River Basin. The Great Lakes Basin is defined to include an area that extends upstream to the point of origin (headwaters) of all streams and rivers flowing into the Great Lakes. The St. Lawrence River Basin is similarly defined to include that area that extends upstream to the point of origin (headwaters) of all streams and rivers flowing into the St. Lawrence River and the Gulf of St. Lawrence. The boundary between the two units is set at the Thousand Islands.

The principal focus of this report is the U.S. side of the Great Lakes Basin. To the extent that logic necessitates, reference will be made to the Canadian side of the basin and to the St. Lawrence River Basin. Unless otherwise stated, all basin references are to the Great Lakes Basin. Also, unless otherwise stated, all statistics presented for the basin as a whole will reflect U.S. and Canadian statistics. Fig. 3 provides a map of the Great Lakes Basin.

PHYSICAL GEOGRAPHY OF THE GREAT LAKES

The Great Lakes - St. Lawrence River Basin consists of 427,000 square miles, extending east-west from a point about 50 miles west of Lake Superior to Quebec City, Province of Quebec, Canada. Its north-south extent extends from Lake Nipigon in the Province of Ontario, Canada to about the center of the State of Ohio (Fig. 3). The Great Lakes Basin proper contains 297,000 square miles while the St. Lawrence River Basin contains the remaining 130,000 square miles. Table 5 provides data on the salient physical features of the lakes.

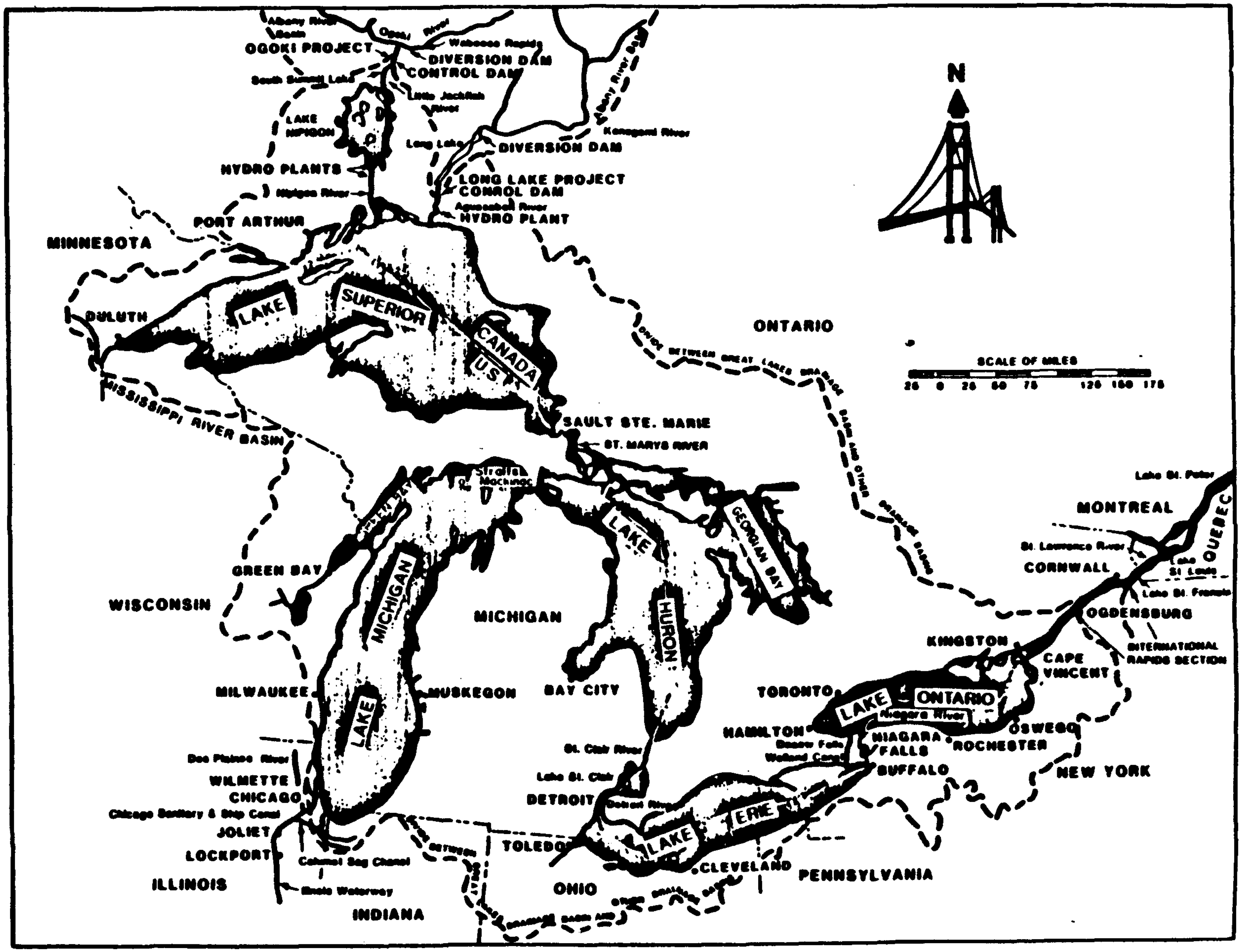


FIGURE 3. THE GREAT LAKES BASIN

TABLE 5. PHYSICAL FEATURES OF THE GREAT LAKES

	Superior	Michiga-	Huron	Erie	Ontario
Elevation (ft.)	600	577	577	569	243
Length (miles)	350	307	206	241	193
Breadth (miles)	160	118	183	57	53
Average Depth (ft.)	483	279	195	62	283
Maximum Depth (ft.)	1,330	923	750	210	802
Volume (cu. miles)	2,900	1,180	850	116	393
Water Area (square miles)	31,700	22,300	23,000	9,910	7,340
Total Drainage Area (square miles)	49,300	45,600	51,700	30,140	24,720
Retention 1/ Time (years)	191	99	22	2.6	6

Source: The Great Lakes: An Environmental Atlas and Resource Book, Ottawa, Canada & Washington, D.C.: Environment Canada and United States Environmental Protection Agency, 1987.

1/ Retention time is a measure based on the volume of water in the lake and the mean rate of outflow.

The Lakes

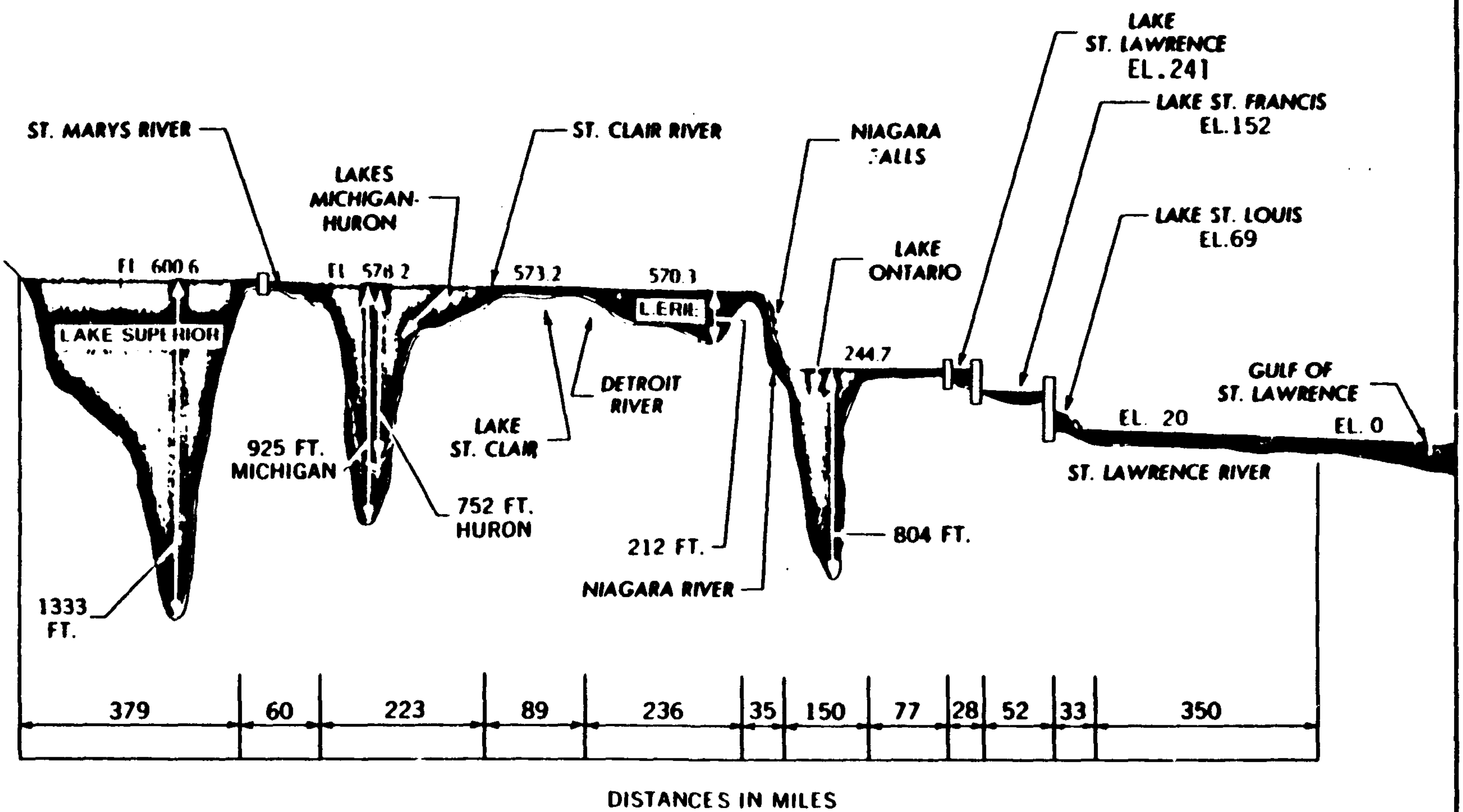
About one-third of the total surface area of the Great Lakes Basin (94,250 square miles) consists of water in the five Great Lakes -- Superior, Michigan, Huron, Erie and Ontario -- and the much smaller Lake St. Clair. Not to be excluded are connecting channels that physically link the lakes. It is estimated that the Great Lakes Basin contains 5,439 cubic miles of fresh water, making it the largest depository of freshwater in the world.

The five Great Lakes differ significantly from each other in physical characteristics. In reviewing the brief description of the physical character of each of the lakes presented below, it is useful to refer to Table 5 and to Figure 4. The latter provides a schematic profile of the five lakes; it is particularly important in understanding the differences in elevation of the lakes.

Lake Superior is the largest of the Great Lakes. Its surface area (31,700 square miles), volume of water (2,900 cubic miles) and retention time (191 years) is greater than that of any other lake. Lake Superior is the deepest of the lakes with an average depth of 483 feet. It is also the lake at the highest elevation -- 600 feet above sea level. Lake Superior empties into Lake Huron via the St. Marys River, which drops 23 feet between the two lakes. Natural rapids and falls on the river necessitated the construction of locks at Sault St. Marie, which permit commercial navigation between Lake Superior and Lake Huron.

Lakes Huron and Michigan are at the same elevation - 577 feet and for purposes of commercial navigation may be considered as one entity. Though they have approximately the same water surface area, 22,300 square miles for Lake Michigan and 23,000 square miles for Lake Huron, Lake Michigan is significantly deeper than Lake Huron; the average depth of the former is 279 feet versus 195 feet for the latter. Thus Lake Michigan has a larger volume of water (1,180 cubic miles) than does Lake Huron (850 cubic miles). The connection between the two, which being at the same elevation is unrestricted, is via the Straits of Mackinac. The connection between Lake Huron at 577 feet and Lake Erie at 569 feet is via the St. Clair River - Lake St. Clair - Detroit River connecting channel.

Lake Erie is significantly smaller than Lakes Superior, Huron and Michigan though it is somewhat larger than Lake Ontario; its water surface area encompasses 9,910 square miles. It is the least deep of the five lakes; its average depth is only 62 feet. The combination of relatively modest size and shallow



ELEVATIONS OF THE LAKE SURFACES ARE AVERAGES (1900-1977) EXPRESSED ON INTERNATIONAL GREAT LAKES DATUM (1955) AND ARE GIVEN TO THE NEAREST TENTH (1/10) FOOT. HORIZONTAL AND VERTICAL SCALES HAVE BEEN DISTORTED TO CONVEY VISUAL IMPRESSION.

FIGURE 4. SCHEMATIC OF GREAT LAKES SYSTEM

depth limits its retention capacity; its water volume amounts to 116 cubic miles, about four percent of the total capacity of Lake Superior. Its average elevation of 569 feet is only eight feet below that of Lake Huron but it is 326 feet above Lake Ontario. The Niagara River, which flows over the Niagara Escarpment at Niagara Falls, N.Y. and Ontario, is the natural outlet of Lake Erie into Lake Ontario.

Lake Ontario is the smallest of the lakes; its surface area is 7,340 square miles. Lake Ontario is much deeper than Lake Erie. The average depth of Lake Ontario is 283 feet whereas the average depth of Lake Erie is only 62 feet. Thus Lake Ontario holds considerably more water (393 cubic miles) than does Lake Erie (116 cubic miles). It is, however, situated at a considerably lower elevation (243 feet) than Lake Erie (569 feet); its average elevation is 326 feet below that of Lake Erie. The outlet from Lake Ontario is the St. Lawrence River which empties into the Gulf of St. Lawrence and the Atlantic Ocean.

Upper vs. Lower Lakes refers to the location of the individual lakes with respect to the Niagara Escarpment. Lakes Superior, Michigan, Huron and Erie, located upstream of the escarpment, are termed Upper Lakes. Lake Ontario, located below the escarpment, is termed a Lower Lake; it is the only Lower Lake.

Connecting Channels

The Great Lakes are interconnected by various connecting channels (Fig. 3). The connecting channels are important in that not only do they channelize commercial navigation on the lakes, they also constrain it. A brief discussion of each is presented below. More information on the constraining effect of each connecting channel is presented later, in the section entitled "Constraints to Commercial Navigation".

The St. Marys River is the connection between Lake Superior and Lake Huron. It is the only connection between Lake Superior and the remaining lakes. All traffic exiting or entering Lake Superior passes through the St. Marys River. There are several passages through the river and the length (as well as the width) of the channel depends upon which passage is utilized. Figure 5 shows a map of the St. Marys River Channel.

Depending upon the route chosen, the St. Marys River channel varies from 63 to 75 miles in length. In that distance the river drops 23 feet from Lake Superior to Lake Huron. Most of this drop (20 feet) occurs at the St. Marys Falls Canal, where four U.S.

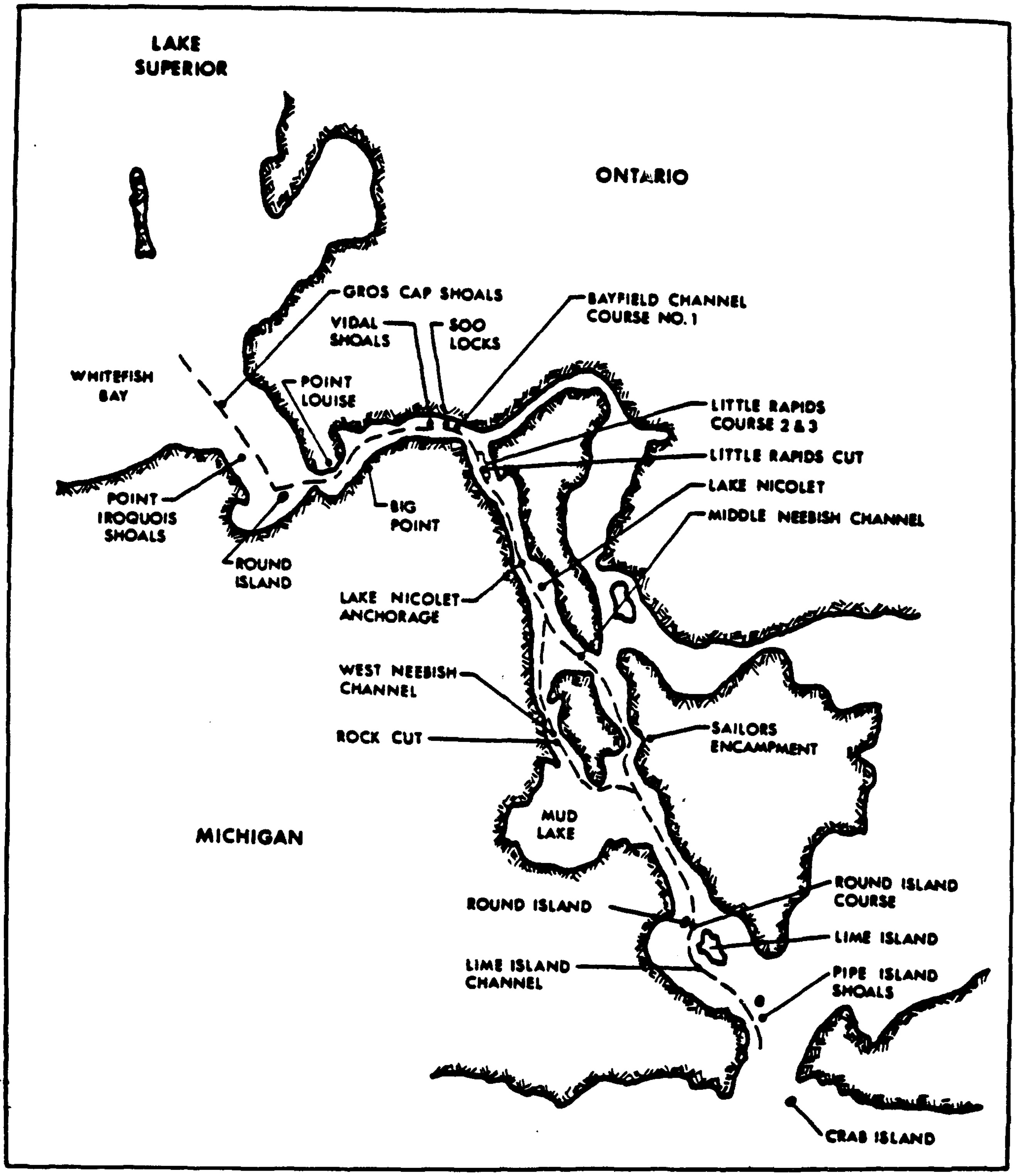


FIGURE 5. THE ST. MARYS RIVER CHANNEL

locks and one Canadian lock permit transit of vessels. Besides providing transit between the two lakes, the locks, associated compensating works, and power houses regulate the flow from Lake Superior into Lake Huron.

The five locks at the St. Marys Falls Canal are collectively know as the "Soo" Locks". The four U.S. locks are the MacArthur, Sabin, Davis and Poe. The lock on the Canadian side is referred to as the Canadian Lock. Because of a physical failure in 1980s, the Canadian Lock is now inoperable. The Sabin Lock on the U.S. side also has been officially closed. Table 6 shows the dimensions of the locks. Figure 6 depicts the Soo Locks.

TABLE 6. PHYSICAL DIMENSIONS OF THE SOO LOCKS
(dimensions in feet)

Feature	MacArthur	Sabin	Davis	Poe	Canadian
Width	80	80	80	110	59
Max. Beam	75	75	75	105	-
Max. Ship Length	730	826	826	1,100	-
Min. Sill Depth	31.0	23.1	23.1	32.0	16.8

Most of the commercial traffic through the Soo Locks uses the Poe and the MacArthur locks. The Sabin and Davis locks are too shallow for most commercial vessels. Of the two that are used, the Poe is the most important as it is the only one capable of passing Class 10 Vessels (vessels of 1,000 feet in length). Since iron ore is the principal commodity transported across Lake Superior, and since most iron ore is now transported in Class 10 vessels, the Poe Lock is effectively the only lock available for the 29 largest vessels of the U.S. Great Lakes fleet.

The Straits of Mackinac connect lakes Michigan and Huron. The two lakes are at the same elevation and in most places the channel is more than a mile wide and 50 feet deep. At two locations, Round Island Passage and the Poe Reef Shoal, channel depth is 30 feet. These two locations function as a constraint to vessels drafting in excess of 30 feet. Figure 7 provides a map of the Straits of Mackinac.

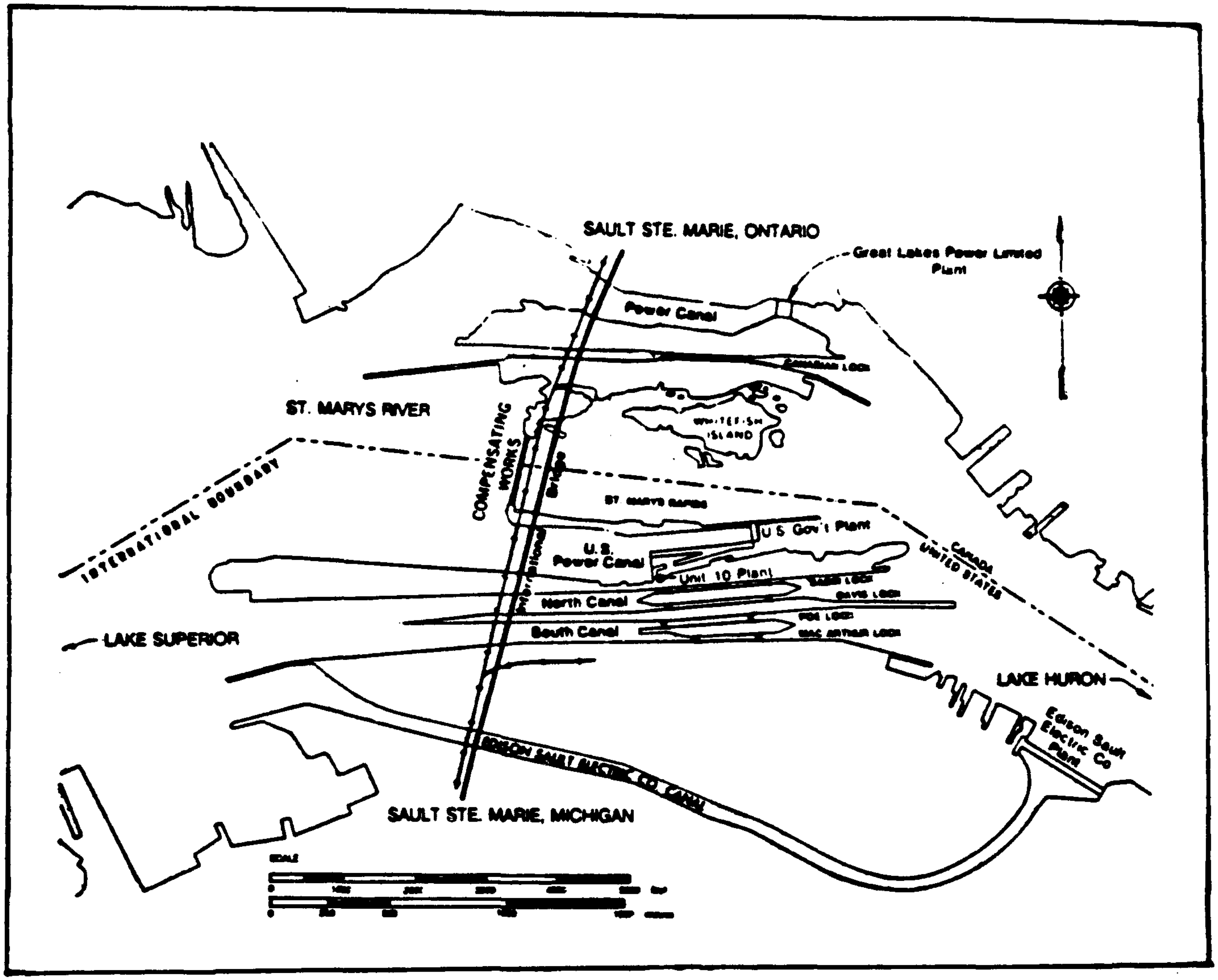


FIGURE 6. THE SOO LOCKS

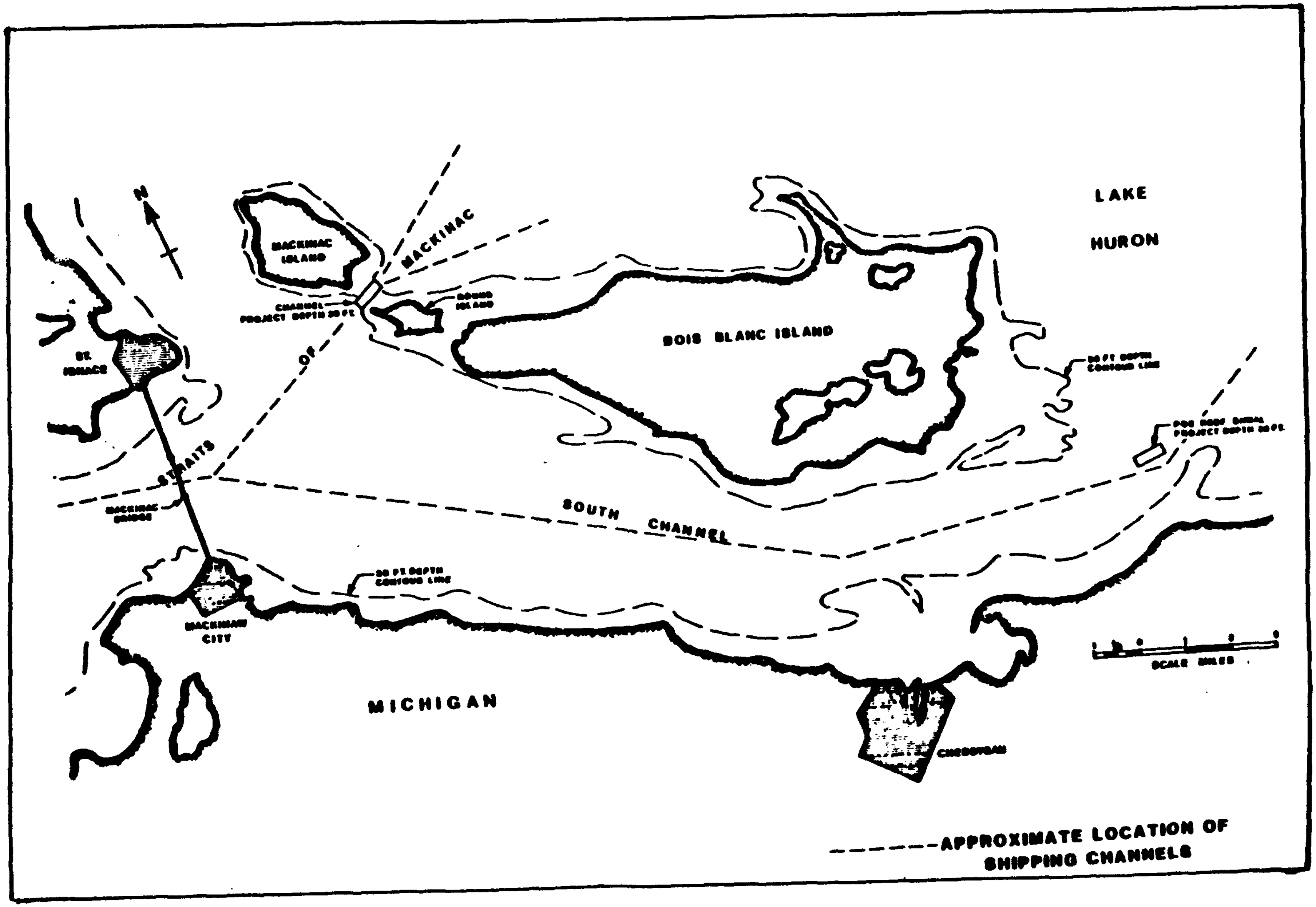


FIGURE 7. THE STRAITS OF MACKINAC

The St. Clair - Detroit River system is the connection between lakes Huron and Erie. It consists of two rivers, the St. Clair and the Detroit, and one lake -- St. Clair. Figure 8 shows the channel.

The St. Clair River, the upstream connection of the system, connects Lake Huron with the much smaller Lake St. Clair. The latter is a shallow basin situated between the St. Clair and Detroit Rivers; its total length is about 89 miles. The Detroit River connects Lake St. Clair to Lake Erie. The total vertical drop in the river system, from Lake Huron to Lake Erie is eight feet. With the exception of a need for dredging at certain locations, the channel is not a constraint to commercial navigation between the two lakes.

The Niagara River connects Lakes Erie and Ontario. In the short span of 36 miles, the river flows from Lake Erie at an elevation of 569 feet into Lake Ontario at an elevation of 243 feet. The vertical drop of 326 feet at Niagara Falls is a barrier to commercial navigation. Were it not for two sets of locks and canals, there would be no exit for commercial vessels from Lake Erie. The two sets of locks/canals are the Welland Canal and the Black Rock Lock and the New York State Barge Canal.

The Welland Canal is the commercial navigation link between Lakes Erie and Ontario. The canal commences in Lake Erie at Port Colborne, Ontario and continues to Lake Ontario, just south and east of St. Catherines, Ontario. The Welland Canal is entirely situated in Canada; its operation is entirely funded and controlled by the Canadian federal government.

The Welland extends across 27 miles and includes eight locks that raise and lower vessels between the two lakes. Figure 9 illustrates the canals. The Welland has been modified such that it can pass vessels of "Seaway" size - Class 7. Such vessels have a maximum length of 730 feet and operate through the system at a maximum draft of 26 feet. Because of the Seaway Size restriction, Class 10 (1,000 foot vessels) cannot navigate through the Welland; they are restricted to navigation within the Upper Lakes.

The Black Rock Lock connects Lake Erie with the New York State Barge Canal. Figure 10 displays a map of the Black Rock Lock and Channel. The lock is situated in the Niagara River at Buffalo, N.Y. Because of the large volume and high velocity of flow, the Niagara River is quite dangerous. The Black Rock Lock and Channel allows recreational and small commercial vessels to bypass the iver and pass up into Tonawanda Harbor, which is the western terminus of the New York State Barge Canal, the current version of the Erie Canal. Very little commercial traffic passes

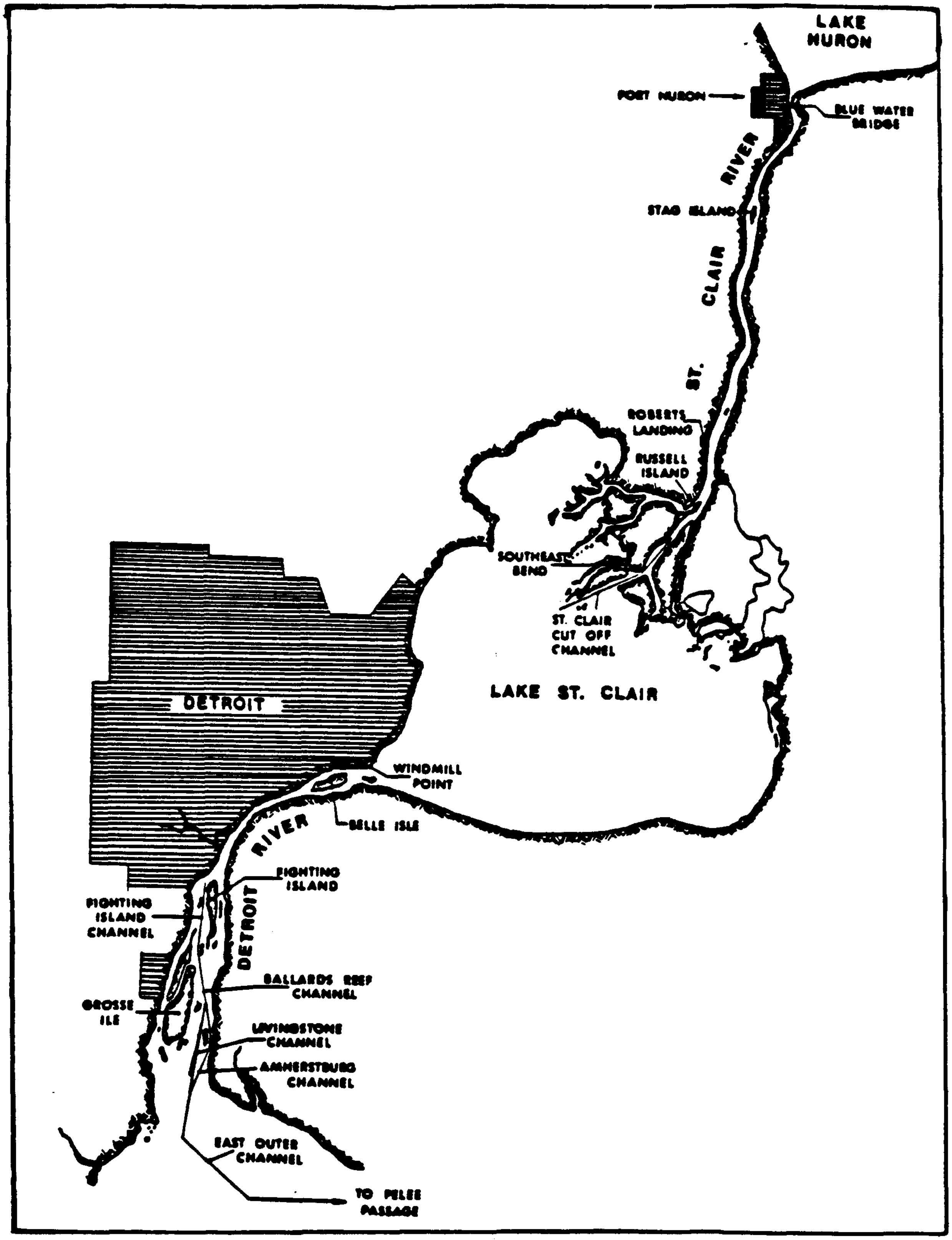


FIGURE 8. THE ST. CLAIR - DETROIT RIVER

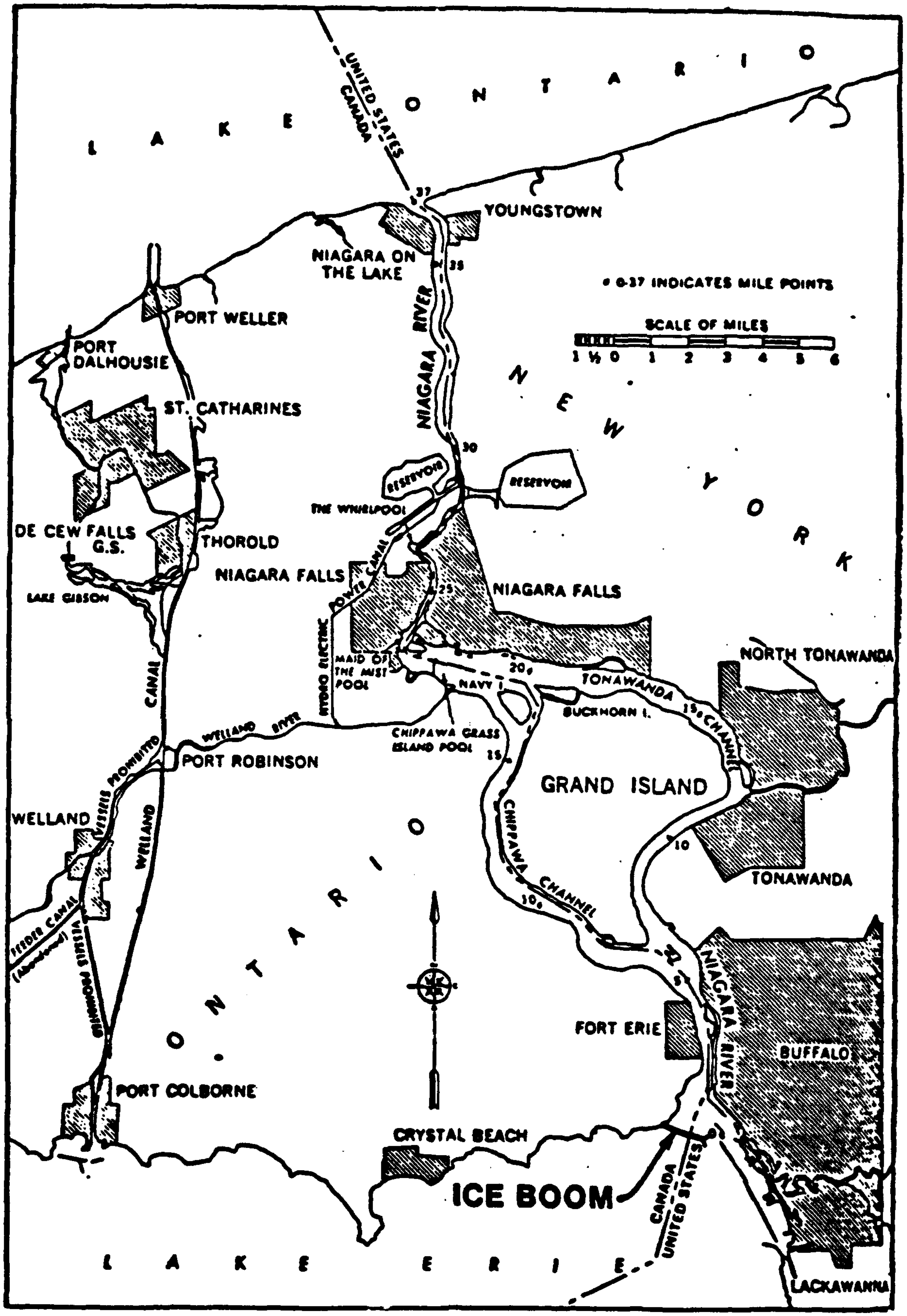


FIGURE 9. THE WELLAND CANAL AND LOCKS

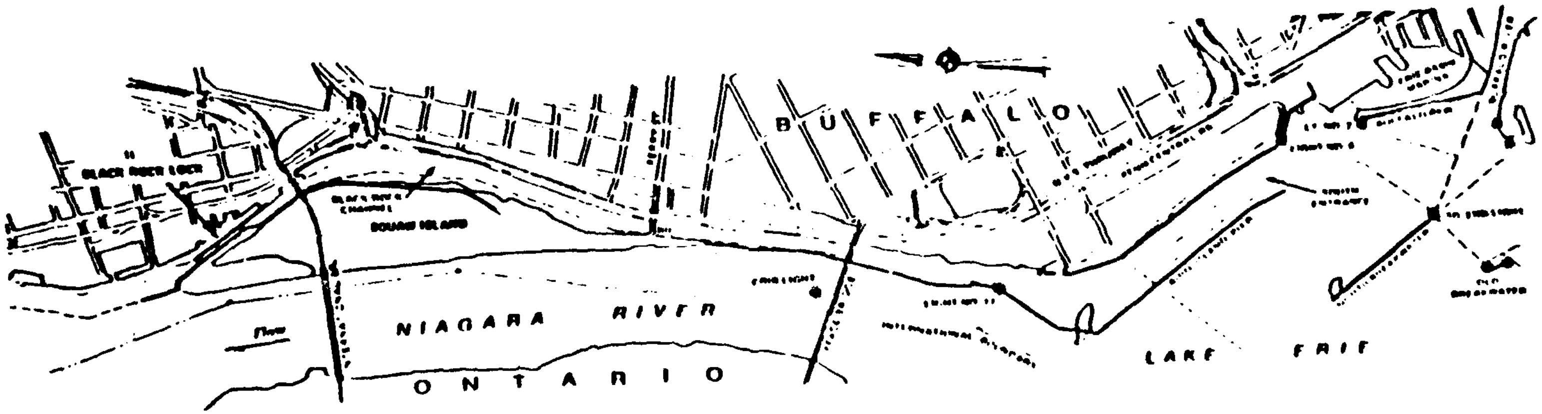


FIGURE 10. THE BLACK ROCK LOCK AND CHANNEL

through the Black Rock Lock and Channel, but what does carries petroleum products to storage facilities at Tonawanda Harbor. Occasionally some coal is transported to a steam electric plant located along the Black Rock Channel. The lock and channel is primarily used by recreational craft passing to/from the New York State Barge Canal and Niagara River to/from Lake Erie.

St. Lawrence Seaway

Ocean vessels enter the inland waterway through the Gulf of St. Lawrence, sailing a further 700 miles westward to the mouth of the river at Father Point. The Seaway itself begins at Montreal, some 340 miles west of the river's terminus and more than 1000 miles from the Atlantic (Figure 11). The river level at the Seaway entrance is 20 feet above sea level, having risen gradually over more than 300 miles. Navigation to this point is assured by the Canadian government, which maintains a minimum navigable depth of 35 feet in this 1000 mile stretch of open water.

From Montreal to Lake Ontario, the vessel travels 182 miles further inland, rising more than 225 feet over this distance. Rapids and lakes alternate throughout this section, providing a scenic background for the commercial water route. The section itself is comprised of five sub-sections, three of which are solely in Canadian waters, the others in international boundary waters.

The first of these subsections, some 31 miles in length, enables marine traffic to bypass the Lachine Rapids and to rise 50 feet above the level of Montreal harbour. Two locks-the St. Lambert, opposite Montreal and the Cote Ste. Catherine, eight and a half miles upstream-are employed to overcome differences in water levels.

After transiting through Lake St. Louis, vessels enter the second subsection-the Soulanges-a 16 mile stretch through the Beauharnois Canal and extending into Lake St. Francis. Here, two locks-in flight-lift ships 82 feet above the lake level of Lake St. Louis.

The third subsection, that of Lake St. Francis, is 29 miles in length and terminates just east of Cornwall, Ontario, headquarters of the St. Lawrence Seaway Authority. This stretch has no locks but required extensive channel improvement and development in order to satisfy navigational requirements. It is the last of the three all-Canadian subsections in the Montreal-Lake Ontario section of the Seaway.

The international segment of the section is entered at the upstream end of Lake St. Francis and extends to a point just east

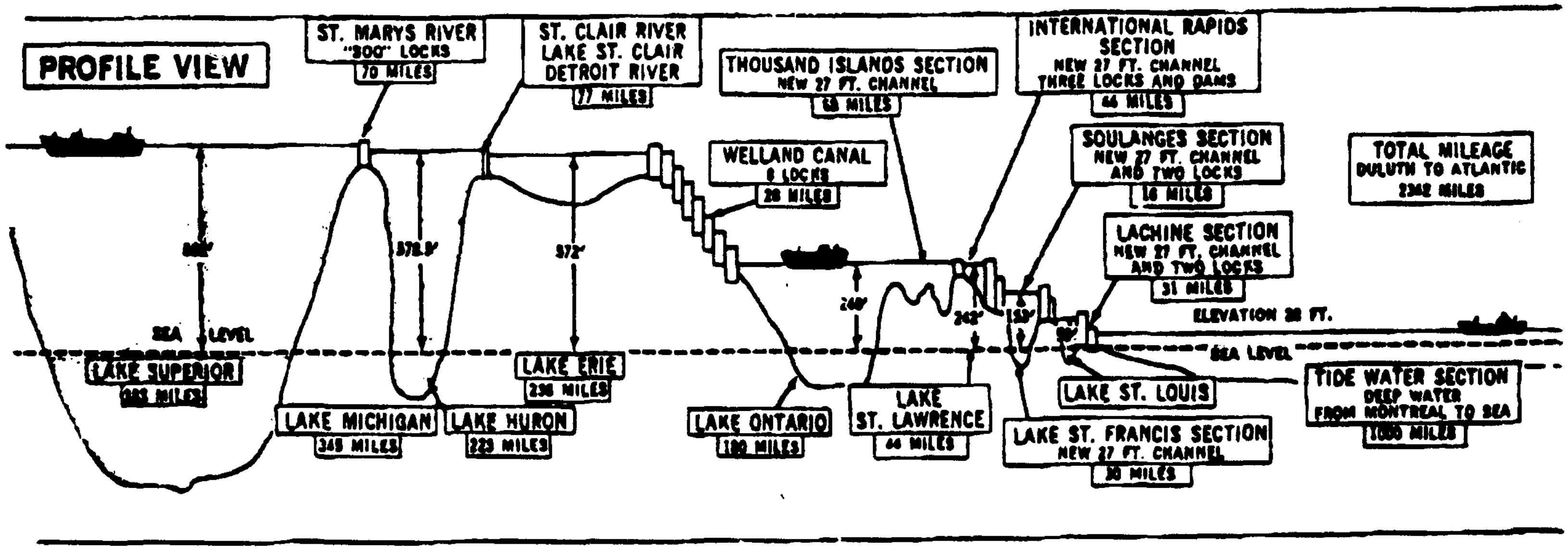


FIGURE 11. THE ST. LAWRENCE SEAWAY

of Ogdensburg, New York. This area used to be a swift-flowing section of the river which rose 90 feet over its 44 mile length. It is now a reservoir, dammed by the Moses-Saunders Power Complexes and known as Lake St. Lawrence, a manmade lake covering some 100 square miles of area. The difference in elevation is overcome by the United States' Eisenhower and Snell locks near Massena, New York-headquarters of the Saint Lawrence Seaway Development Corporation-and by the Canadian control lock at Iroquois, Ontario.

The remaining subsection of the river journey, extending over 68 miles of waterway into Lake Ontario is known as the Thousand Islands section, and is maintained by the United States Seaway Corporation. It is free of rapids but many rock shoals were removed when the channels were widened and deepened.

There are seven new locks in the St. Lawrence River, five in Canada operated by The St. Lawrence Seaway Authority of Canada, and two in the United States operated by the St. Lawrence Seaway Development Corporation. All locks are similar in size. The specifications are:

Length, breast wall to gate fender (Ships may not exceed 730 feet in overall length)	766 feet
Width	80 feet
Depth over sills	30 feet
Locks:	Lift
St. Lambert	13 to 20 feet
Cote Ste. Catherine	33 to 35 feet
Lower Beauharnois	38 to 42 feet
Upper Beauharnois	36 to 40 feet
Snell	45 to 49 feet
Eisenhower	38 to 42 feet
Iroquois	.5 to 6 feet

Lake Levels

Given their large surface area and considerable depth, the Great Lakes retain a large volume of water; they are the largest reservoir of freshwater on the surface of the earth. To a significant degree, the Great Lakes regulate themselves. However, the volume of water and thus the level (elevation) of the water surface varies; it varies seasonally (from month to month) and secularly (from one year to another). Though the amount of variation is not insignificant, particularly to individual user groups who are accustomed to and have adjusted to a limited range of variation, neither is it great.

Water levels in the Great Lakes have been monitored since 1860; thus there is a long record of mean monthly water surface

elevations for the individual lakes. Figure 12 presents the seasonal variation in the mean level of each lake. The range of variation in monthly mean levels from the lowest to the highest elevation is about 1.0 foot for Lake Superior to 1.6 feet for Lake Ontario. The variation for the remaining lakes - Michigan, Huron and Erie - lies between these figures. As expected of a mid latitude location, mean water levels are at minimum in winter and at a maximum in summer, mostly in early summer, when they begin to decline to the winter minimum.

Long-term (secular) fluctuations in lake levels on the Great Lakes are not predictable as various factors that affect the levels, principally climatological factors, cannot be predicted. The best available indicator of long-term fluctuations is the historic record of water levels for the five lakes. Figure 13 presents annual average water levels for each of the five lakes for the 1950-88 period. In that interval the variation from extreme high to extreme low monthly means has been: 4.0 feet on Lake Superior; 6.0 feet on Lakes Michigan, Huron and Erie; and 6.5 feet on Lake Ontario. These are not absolute limits. Geologic and archaeologic evidence for the past 2,500 years indicates even greater variations have occurred.

Not all the water loss from the lakes is due to natural causes; some has been diverted by human activity. There are three physical locations where water has been physically diverted into or out of the Great Lakes Basin (Figure 14).

There are two diversions that divert water <u>into</u> the Great Lakes Basin. These two diversions are Long Lac and Ogoki, both in Canada. Each diverts some of the tributary flow of the Hudson Bay southward into the Lake Superior basin. The effect of these two diversions into the lake is to raise the level of the Great Lakes by very minor amounts.

One diversion, the Sanitary Ship Canal at Chicago, diverts water <u>out</u> of the Great Lakes Basin. This diverts water from the Great Lakes into the Illinois River and eventually the Mississippi River for purposes of sanitation, navigation and hydro-electric production. It lowers water levels of the Great Lakes by minor amounts.

There are two diversions that are interbasinal -- they divert water from one Great Lakes watershed to another but do not divert water from the Great Lakes Basin as a whole. These are the Welland Canal in the Province of Ontario and the New York State Barge Canal. The Welland Canal passes water from Lake Erie to Lake Ontario and thus does have some minor effect in lowering water levels on Lakes Erie, Michigan and Huron. The New York State Barge Canal has two interconnections with the Great Lakes, one into the Niagara River at Tonawanda, N.Y. and a second at

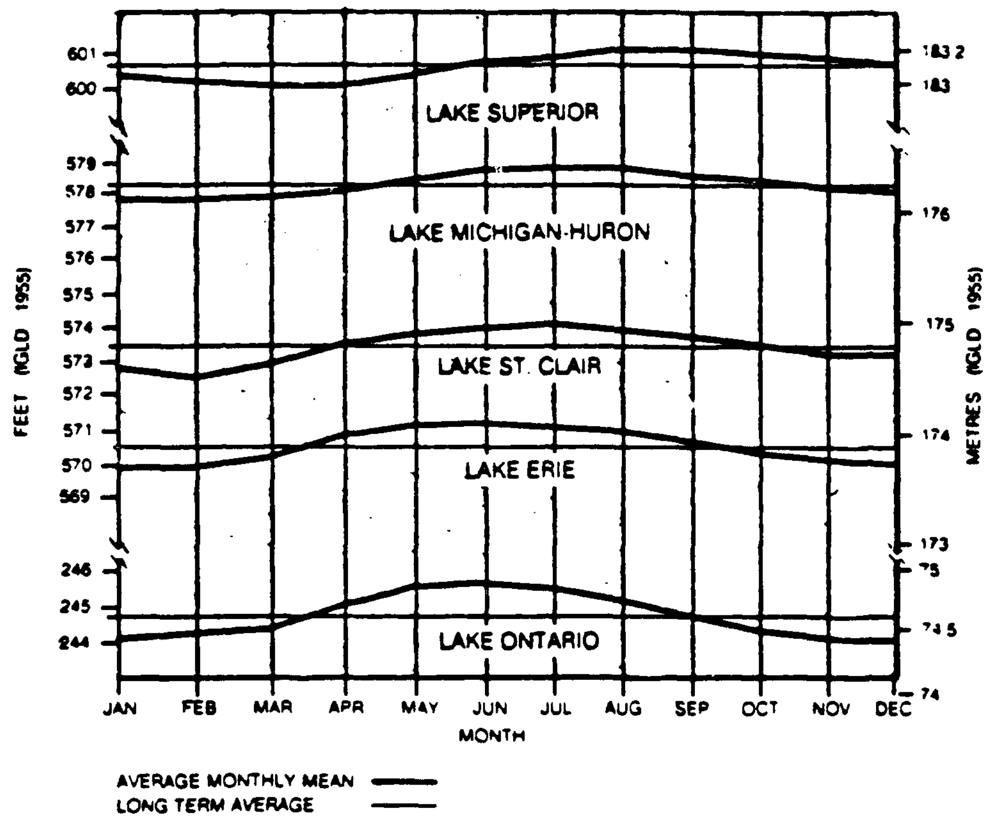


FIGURE 12. SEASONAL FLUCTUATIONS IN GREAT LAKES LEVELS, 1900-1988

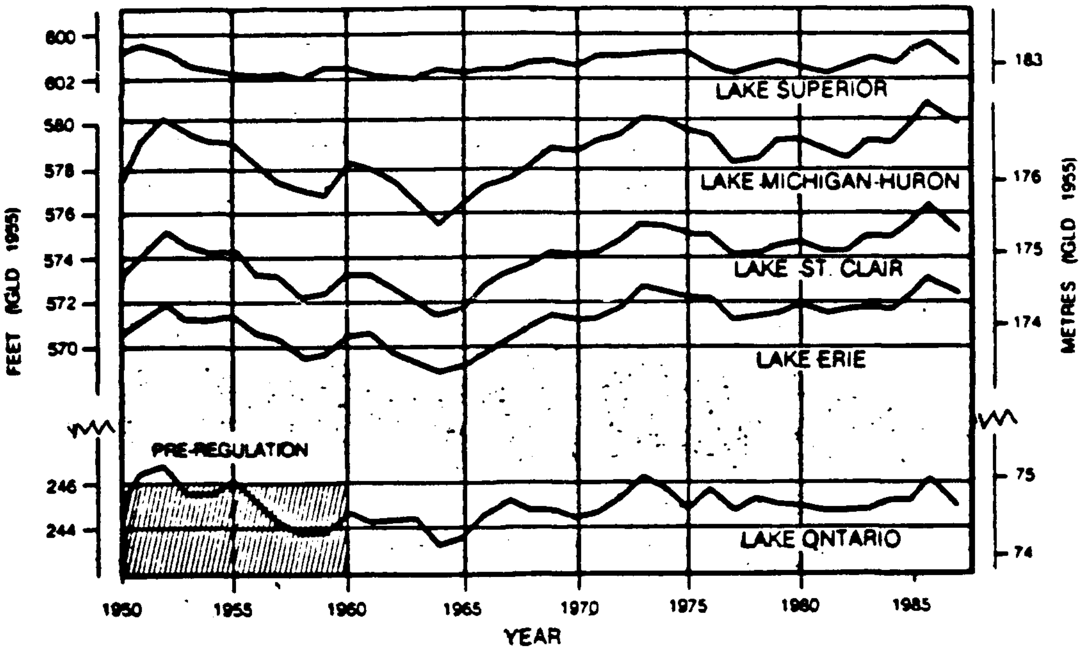


FIGURE 13. ANNUAL AVERAGE GREAT LAKES WATER LEVELS, 1950-1988

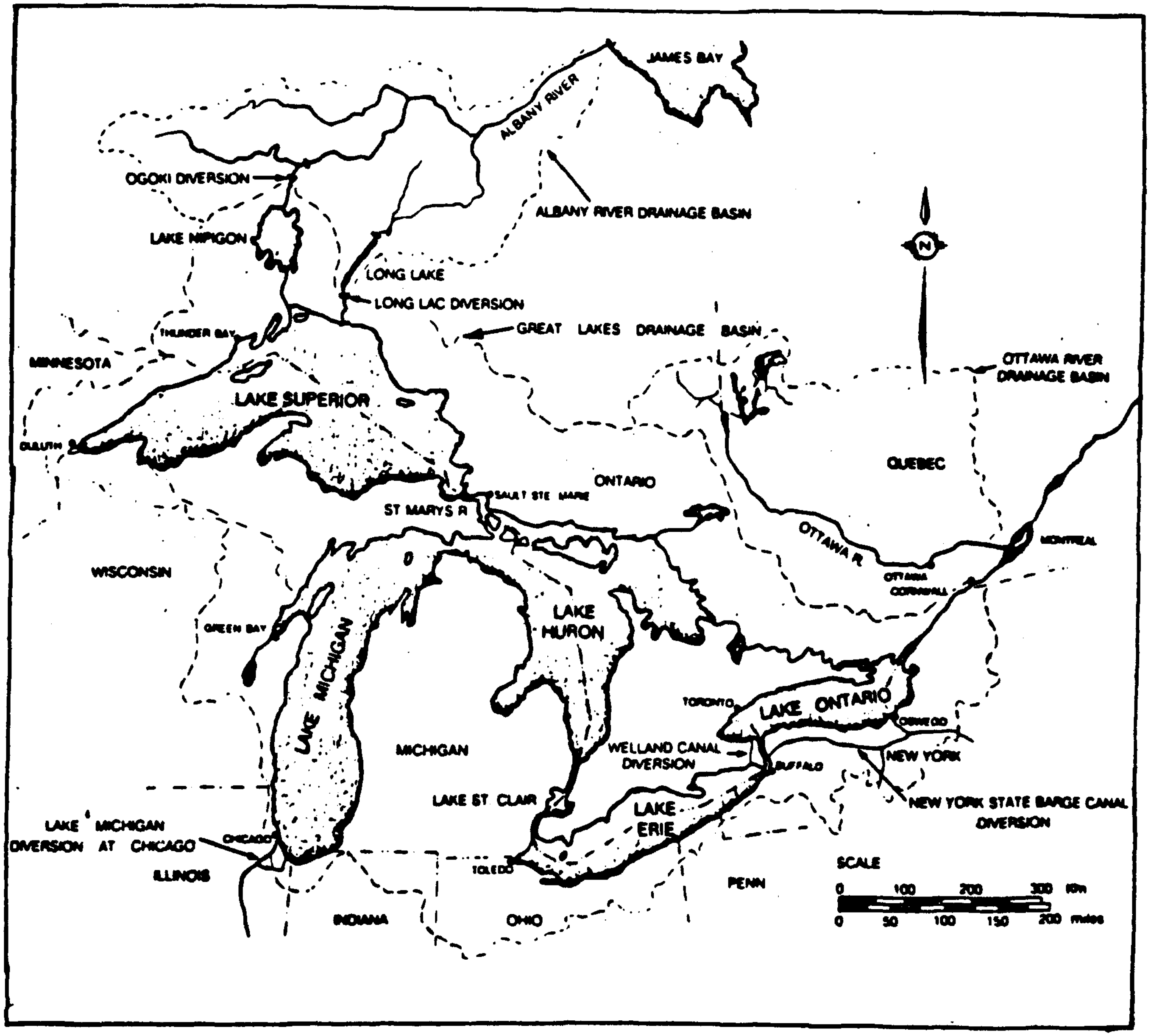


FIGURE 14. GREAT LAKES DIVERSIONS

Oswego, N.Y. In both cases, however, the canal is part of a natural river system and thus has no significant effect on the lake levels.

Channel and/or shoreline modifications have been undertaken in two connecting channels: the Detroit - St. Clair River system and along the Niagara River. In the case of the Detroit - St. Clair Rivers system, there has been substantial channel dredging to facilitate commercial navigation; additionally, dikes have been constructed for confinement of the dredged material. These modifications have lowered the levels of Lakes Michigan and Huron by minor amounts. Channel and shoreline modifications also have been constructed along the Niagara River. Additionally, construction of two bridges and of the Black Rock Lock at Buffalo have caused restrictions in the flows of the Niagara River, which in turn has had the effect of raising the level of Lake Erie by very minor amounts.

Lake Regulation

Two of the Great Lakes, Superior and Ontario, are regulated to affect the level of their water surfaces. In both cases the regulation does not ensure full control of the levels of the lake because the major factors that affect the supply of water to the Great Lakes -- over-lake precipitation, evaporation and runoff -- can neither be controlled nor can they be accurately predicted over the long term. The impact of regulation upon water levels of Lake Superior has been small compared to the natural factors that effect its water level. Upon various occasions, the regulation of Lake Ontario has had a significant effect on its water level.

<u>Lake Superior</u>. Regulation was first applied to Lake Superior by the International Joint Commission (IJC) Order of Approval issued in 1914 which permitted the construction of hydroelectric facilities on the Canadian and U.S. sides of the St. Marys River. The IJC Order also established the International Lake Superior Board of Control to oversee the operation of the facilities in the St. Marys River. The Lake Superior Board has two members: one from the U.S. Army Corps of Engineers and one from Environment Canada.

The 1914 Order established the basic objective for, and the limits to, regulation. A principal condition specifies a target range for the water surface elevation. Regulation was to be done "in such manner as not to interfere with navigation." The 1914 IJC consent order has been updated over the years to meet the changing condition and requirements of the Great Lakes-St. Lawrence River System. In 1979 the IJC further amended its Order of Approval to require that the levels of Lakes Michigan-Huron also be taken into account in determining Lake Superior's outflows. The amendment also specified that adequate flows must

be ensured for fish habitat in the rapids section of the St. Marys River.

Physical facilities that have been constructed to control the flow through the St. Marys River are three hydropower plants (one in Canada and two in the U.S.), five navigation locks (four in the U.S. and one in Canada) and the 16-gate Lake Superior Compensating Works. The last was built to compensate for the increased outflow capacity of the St. Marys River that resulted from the hydropower developments.

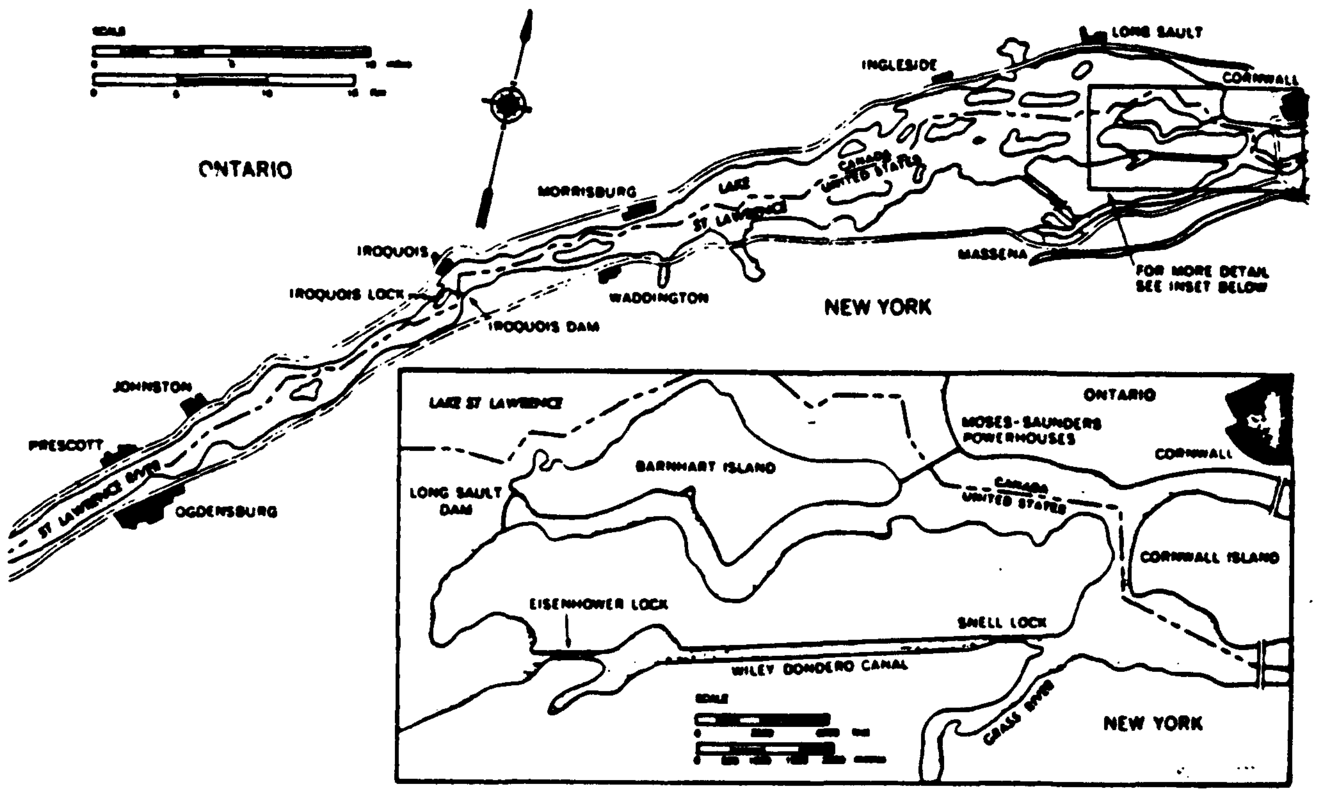
The IJC issued four different regulation plans to regulate Lake Superior between 1928 and 1979. In all four the main factor considered in determining outflows into the St. Marys River was the level of Lake Superior. In its 1979 Order of Approval the IJC implemented Plan 1977. This plan differed from its predecessors in that it required consideration be given to the levels of Lakes Michigan-Huron when determining outflows.

Lake Ontario. Regulation of Lake Ontario was made possible by construction of the hydropower facilities along the international reach of the St. Lawrence River. The IJC issued its initial Order of Approval in 1952 authorizing Ontario Hydro and the New York Power Authority to construct and operate the facilities.

In 1956 the IJC amended its order to include regulation criteria designed to reduce the range of levels experienced on Lake Ontario, to facilitate navigation in the St. Lawrence River, and provide protection for riparian and other interests upstream and downstream in the Province of Quebec. The amended order also established the International St. Lawrence River Board of Control to ensure compliance with provisions of the orders by operators of the facilities.

Upon completion of construction in 1960, the Board began to implement its charge. Currently, the Board consists of thirteen members. The members represent the U.S. Army Corps of Engineers, Transport Canada, Environment Canada, states, provinces and local communities.

Three dams were constructed on the St. Lawrence River as part of the hydroelectric project -- the Moses-Saunders, Long Sault and Iroquois (Figure 15). The Moses-Saunders power dam is the principal regulatory structure. The dam at Long Sault, New York acts as a spillway when outflows from Lake Ontario are larger than the capacity of the power dam. The dam at Iroquois, Ontario can be used to regulate flows, but it is principally used to assist in the formation of a stable ice cover in the winter and to prevent water levels from rising too high in Lake St. Lawrence, upstream of the power dam.



LAKE ONTARIO CONTROL STRUCTURES

FIGURE 15. LOCKS AND DAMS ON THE ST. LAWRENCE RIVER

Three plans have been used to regulate the outflows of Lake Ontario; the current plan is Plan 1958-D. It consists of a family of operating curves for different trends in the water supply conditions for Lake Ontario. Depending upon the supply conditions in the lake, a specific curve is selected and the outflow is adjusted accordingly.

As with Lake Superior, the regulation of Lake Ontario does not ensure full control of the levels of the lake because the same major factors that affect the water supply -- precipitation, evaporation and runoff -- are not controlled. Further, it should be noted that fluctuations of Lake Ontario's water level cannot affect the upstream lakes because of the presence of Niagara Falls.

On some occasions the impact of regulation of Lake Ontario has been significant (Fig. 16). In the extreme low water period of the mid-1960s, the lake's level was maintained slightly higher than would otherwise have been the case. In the high water period of 1969-1988, the lake's level was maintained somewhat lower than it would otherwise have been. Toward the end of that high water period, in 1986-1988 when water levels were unusually high, the lake's level was maintained as much as 2.9 feet below what it would have been without regulation.

In some cases regulation of Lake Ontario has not been as successful. In the early and mid-1970s, when the water level was critically high, the water level was held to more than a foot below pre-project levels. However, despite regulation, the water level of the lake reached 248.0 feet, more than a foot above the IJC's target level of 246.8 feet.

Constraints to Commercial Navigation

All five of the Great Lakes are deep enough such that the lakes are not a constraint to commercial navigation. The only exception to this is that the approach channel to individual harbors may require dredging. It is the connections between the lakes (connecting channels) that are the principal natural constraints to commercial navigation on the lakes. In addition, the climate within the basin places a significant constraint on navigation across the lakes.

Climatic Constraints

The fundamental constraints to commercial navigation are depth of water and climate. In the long term the two are interrelated in that the volume and depth of water in the lakes are affected by long term, continental changes in climate. For

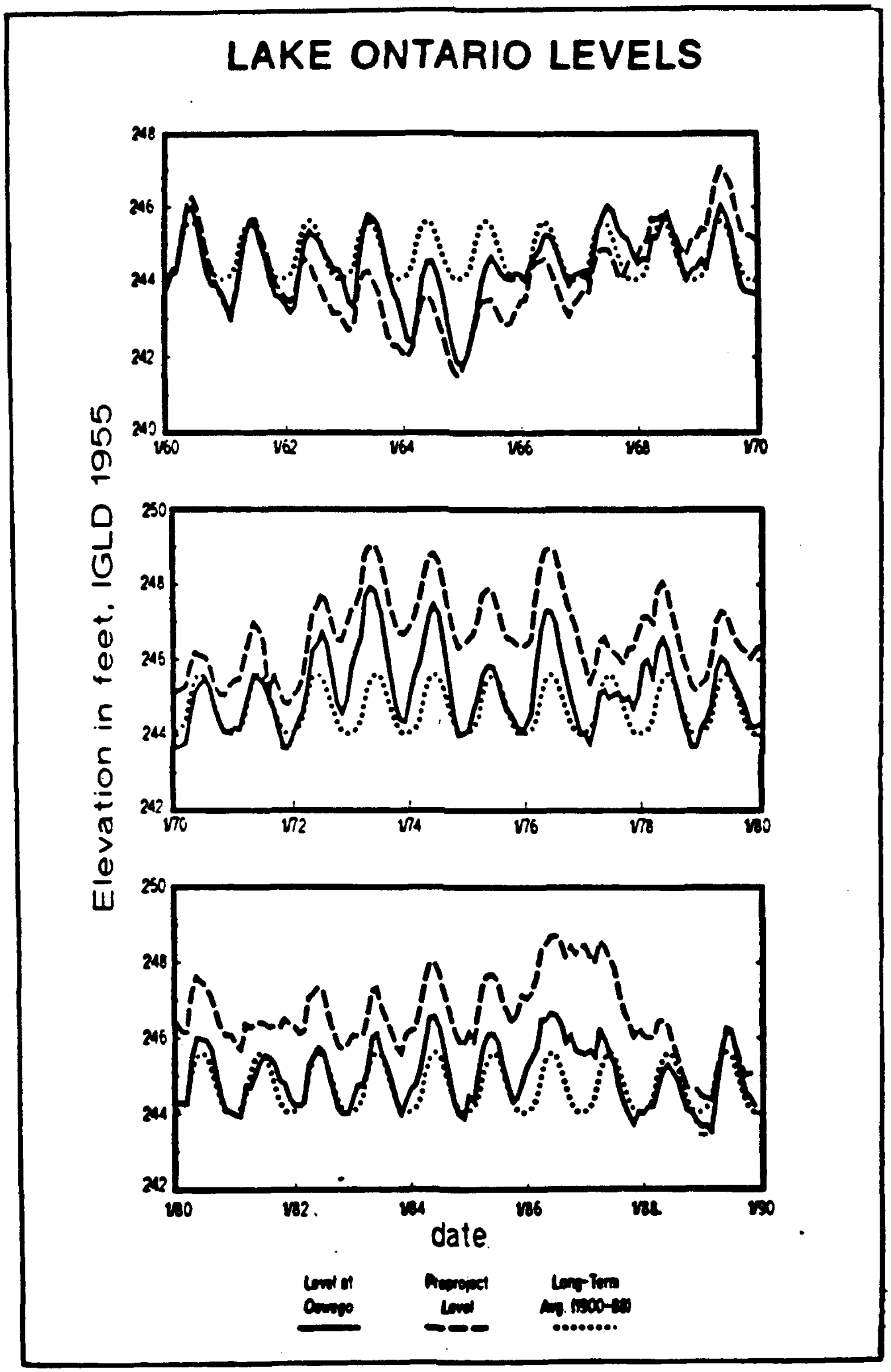


FIGURE 16. EFFECT OF REGULATION ON LAKE ONTARIO

all practical purposes changes in the climate of this magnitude are not relevant in that they occur over very long periods of time -- thousands of years. The only qualification to that is the present concern about global warming.

Short term variations of climate that are significant largely relate to variations in the amount of precipitation falling within the Great Lakes Basin. These fluctuations tend to occur over a period of a few to several years. Deficiencies in precipitation tend to produce a lowering of water levels in the lakes while precipitation excesses tend to produce a rise in lake levels. Such variations have occurred in the past and will continue to occur in the future; they are the reason lake levels are regulated.

In addition to variations of climate that exist from year to year, there are seasonal variations in the volume of water, and thus in the level of the water surfaces of the lakes, that are the indirect effect of climate. This is the annual pattern of seasonal variation due to the seasonal pattern of precipitation in the Great Lakes Basin and to seasonal variations in runoff.

The Great Lakes Basin receives a slight majority of its precipitation in the summer months when precipitation falls in the form of rain. It receives less than half of its annual average amount in the winter months when much, but not necessarily all, of the precipitation comes in the form of snow. Unless there is a winter rain on top of the snow cover, runoff in the winter is less than in summer. Thus, lake levels tend to fall in autumn/winter and to rise in spring/summer.

This seasonal fluctuation in lake levels is significant to commercial navigation on the lakes and to the Corps of Engineers maintenance dredging program. Because lake levels are significantly higher in spring and early summer, the vessels are able to load to a deeper draft thus reducing their costs per ton of commodity transported. As the summer season progress into autumn and winter, and lake levels decline, the fleet operators must necessarily load their vessels to a lesser draft with a corresponding increase in unit transportation costs.

The effect on the Corps' dredging program is not as obvious. The location, magnitude and timing of dredging is affected by numerous variables. However, all other things being equal, at individual harbors such as Cleveland, the Corps can defer dredging from spring into summer because of the seasonally high lake levels in the Spring season; if necessary, the normal pattern of seasonal variation of lake levels allows the Corps to defer dredging until later in the navigation season.

Seasonal climatic change in the mid-latitudes produces ice in the winter. Ice on the Great Lakes, principally ice at the Soo

Locks and ice in the connecting channels between the lakes, limits the extent of the navigation season. Extension of the season, which is physically possible, would reduce transportation costs on the lakes but it would increase other costs. Additionally, it would introduce environmental effects that are of considerable concern. For the time being at least, the onset of winter and ice conditions limits the navigation season.

Connecting Channels as Constraints

The connecting channels are the "bottlenecks" through which vessels must pass if they navigate more than one lake. If a vessel stays within one lake, the vessel is not affected by a connecting channel.

There are five physical connecting channels within the Great Lakes Basin:

1. the St. Marys River and Soo Locks connect Lakes Superior and Huron;
2. the Straits of Mackinaw connect Lakes Michigan and Huron;
3. the St. Clair - Detroit River system connects Lakes Huron and Erie;
4. the Niagara River connects Lakes Erie and Ontario; and,
5. the Welland Canal, connects Lakes Erie and Ontario.

The critical statistics of each connecting channel are presented in Table 7.

Of the five the Welland Canal is entirely a Canadian facility. It is an important element as it is the only way commercial navigation vessels can move between Lakes Erie and Ontario. Because of Niagara Falls, the passage of the Niagara River over the Niagara Escarpment, the Niagara River is not a commercial navigation channel.

The Straits of Mackinac are a constriction but not a constraint to commercial navigation upon the Great Lakes. In general, the channel is more than one mile in width with a depth in excess of 50 feet. There are only two locations within the Straits that approach being a constraint; they are the Round Island Passage between Round Island and Mackinac Island and the Poe Reef Shoal in the South Channel (Figure 7). The width of the Round Island Passage narrows to 1,250 feet. Both areas have a depth of 30 feet, more than adequate for most lake vessels. It should be noted, however, that when fully loaded with iron ore, some Class 7 and Class 8 freighters, and most Class 10s, draft more than 30 feet.

TABLE 7. CRITICAL DIMENSIONS OF THE CONNECTING CHANNELS

Channel	Controlling Depth (ft.)	Length (miles)	Channel Width (ft.)	Fall (ft.)	Restrictive Width 1/ (ft.)
St. Marys River	27.0	63-75	300-1,500	22	75-105 2/
Straits of Mackinac	30.0	.8	1,250	0	1 Mile
St. Clair River	27.0	46	700-1,400	4/	600 3/
Lake St. Clair	27.5	17	700-800	8	NA
Detroit River	27.5	32	300-1,260	4/	800
Welland Canal	27.0	27	192-350	326	76 5/

1/ Lock widths show maximum ship size allowed.
2/ 75 feet restrictive width for the MacArthur, Sabin and Davis Locks; 105 feet for the Poe Lock.
3/ Width restrictions at the Blue Water Bridge.
4/ The total fall in the St. Clair - Detroit River Systems is 8 feet.
5/ Lock restrictions.

The St. Marys River Channel and the Soo Locks are a major constraint to commercial navigation passing between Lakes Superior and Huron. Since the principal commodity transported across Lake Superior is iron ore, this channel primarily affects the shipment of iron ore. Moreover, iron ore is the principal commodity transported across the lakes as a whole. Maintenance of this commodity flow is essential to maintenance of the Great Lakes as a commercial navigation system. Without the flow of iron ore, commercial navigation on the Great Lakes would be greatly diminished and the spatial pattern of commodity flows would be drastically altered.

The St. Marys River channel is narrow (Figure 5). Except where one-way traffic is imposed, the width of the channel is adequate for two-way navigation. The channel is maintained to a project depth of 27 feet with the aid of dredging.

Ice is a problem along the St. Marys River channel. One aspect of the ice problem is "pack ice". It consists of broken pieces of ice that have been consolidated and jammed together by winds and currents. Accumulations of pack ice increases with each winter storm. Eventually the pack can extend from 15 feet above the water surface to 30 feet below the water surface. Since the pack develops to this extent during mid and late winter when the Soo Lock is closed, it normally does not impact commercial navigation.

"Slush ice" offers more resistance to navigation than does pack ice. On occasions slush ice develops to a depth of 6 to 8 feet and at this depth it can stop the movement of a lake vessel. In spring, wind and current conditions can drive slush ice from Lake Superior into the St. Marys River so that the accumulations extend from the surface to the bottom of the river. In these cases the channel will be closed for a period of two to three days.

Water level fluctuations in the St. Marys River are sizeable. The water level has been known to fluctuate as much as 5 feet within three hours. Since much of the sailing route is dredged channel, these water level changes can affect safe vessel draft in the short run.

The St. Clair - Detroit River System consists of the St. Clair River, Lake St. Clair and the Detroit River. The St. Clair River connects Lake Huron with the much smaller and less deep Lake St. Clair while the Detroit River connects Lake St. Clair with Lake Erie (Figure 3). Lake St. Clair is basically a shallow basin between the St. Clair and Detroit Rivers. It has to be dredged to maintain a channel depth of 27.5 feet with a width of 800 feet. At two locations, channel width is only 600 feet.

Ice conditions do develop along this channel. Ice tends to accumulate at the entrance of the St. Clair River, having drifted in from Lake Huron. The river freezes over during severe weather conditions, which usually occur after the end of the navigation season. Ice accumulates in the shallow Lake St. Clair, and the lake usually freezes over by the end of January. Once again, however, this is normally beyond the end of the navigation season.

Fluctuating water levels on an hourly basis are a problem on the Detroit and St. Clair Rivers. The change is most severe on the Detroit River where the water elevation can change as much as 6 feet in 8 hours. The change is not as great on the St. Clair River, but the change comes more rapidly. Its water elevation has been known to rise 2 feet in a short time because of high winds. Since much of the sailing route is dredged channel, these water level changes can affect safe vessel draft in the short run.

CHAPTER 4

THE GREAT LAKES FLEET

A combination of size constraints and the sometimes boisterous weather and wave conditions has produced a unique vessel type serving the Great Lakes. Vessel length and beam, especially the latter, are limited by lock dimensions. Vessel depth or draft is limited by the depth of connecting channels. The result is a vessel that is longer, narrower, and much shallower than its oceangoing counterpart, for vessels of like capacity. Lakes vessels are so distinctive, they are called "boats," not ships. The largest are too big for Welland Canal and Seaway locks, and only operate on the "Upper Lakes." The Welland and Seaway lock sizes also limit entry into the Lakes to small oceangoing vessels. In 1991, there were 480 transits of "salties" through the seaway, mostly European vessels carrying finished steel products to U.S. ports.

The Coast Guard is relaxing regulations regarding barge traffic on the Great Lakes. For the first time in 1992, certain types of barges are being allowed to transit from Chicago, IL. to Milwaukee, WI. There are very few U.S. or Canadian-flag oceangoing bulk carriers or containerships small enough to serve the Lakes; hence direct overseas trade is dominated by vessels of other countries. Predominantly, commerce on the Lakes is between U.S. ports, between Canadian ports, or between ports of those two countries. Cabotage laws restrict use of foreign vessels in domestic trade, hence the unique "Lakes boat" fleet is exclusively U.S. or Canadian vessels. This chapter focuses on that fleet.

There are three ways of classifying the commercial navigation fleet on the Great Lakes: by nation, by vessel type and by vessel size. This chapter examines the fleet in terms of its composition by vessel type and size. It also examines changes that have occurred in the fleet in the past two decades. Throughout, a distinction will be drawn between the United States and Canadian fleet. Finally, there is a short discussion on the effect of vessel size on transportation rates.

COMPOSITION OF THE FLEET BY VESSEL TYPE

There were 185 commercial vessels operating on the Great Lakes in 1990 compared to 277 in 1973 and 302 in 1980 (Table 8 and Fig. 17). While the total fleet grew by 9% from 1973 to 1980, it declined by 39% from 1980 to 1990. Most of the decline occurred in the American fleet. In the seventeen years from 1973 to 1990 the American fleet declined by 53%; the corresponding decline in the Canadian fleet was 14%.

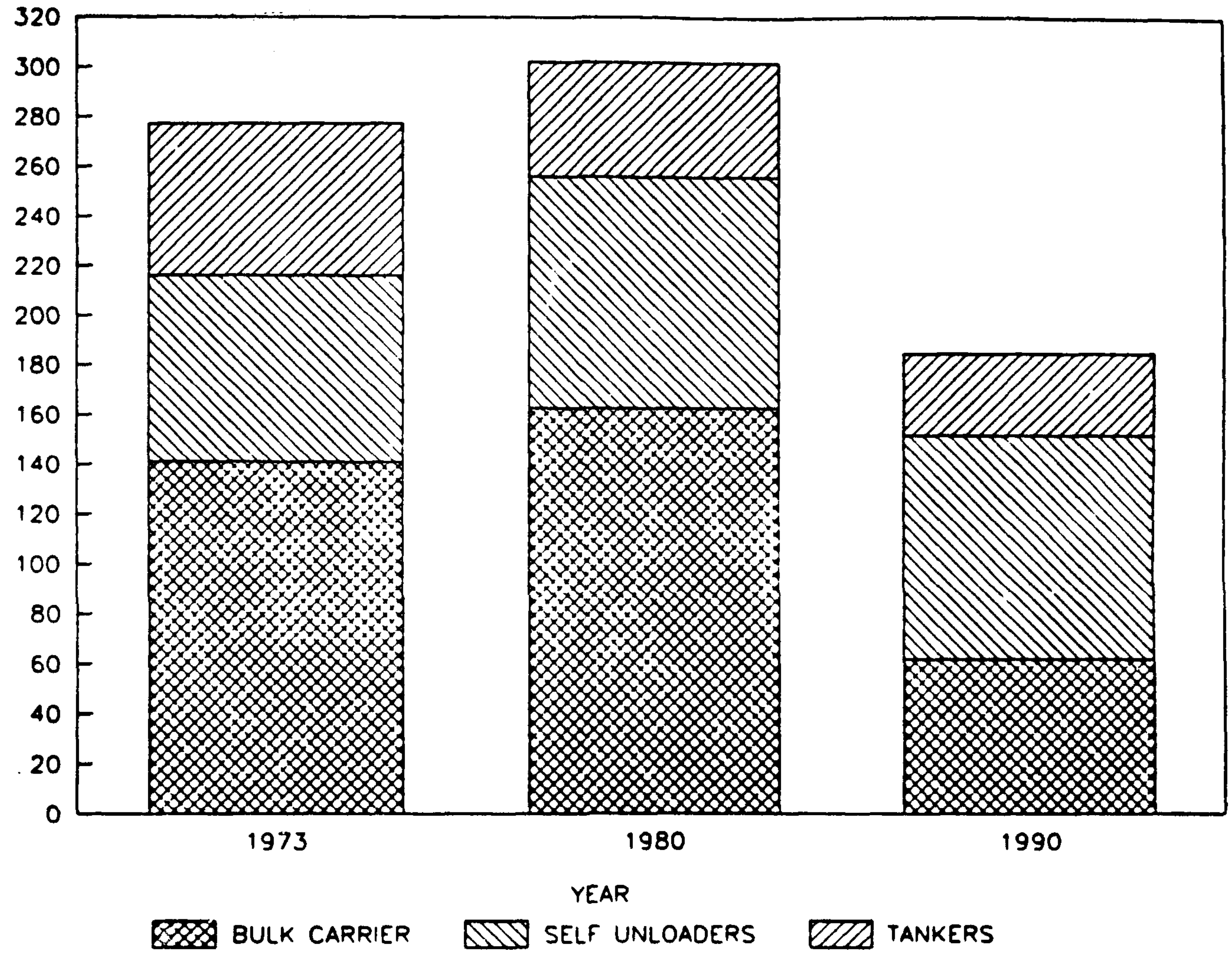


FIGURE 17. GREAT LAKES FLEET BY VESSEL TYPE, 1973, 1980 AND 1990

TABLE 8. COMPOSITION OF THE GREAT LAKES FLEET BY VESSEL TYPE AND NATIONALITY, 1973, 1980 AND 1990.
(Percent)

Type of Vessel	Navigation Season 1973	1980	1990	Percent Change 1973-1990
Bulk Carriers				
United States	78	78	7	-91.0
Canada	63	85	55	-12.7
Subtotal	141	163	62	-56.0
Self Unloaders				
United States	47	58	55	17.0
Canada	28	35	35	25.0
Subtotal	75	93	90	20.0
Tankers				
United States	19	14	6	-68.4
Canada	42	32	27	-35.7
Subtotal	61	46	33	-45.9
Total Fleet	277	302	185	-33.2
United States	144	150	68	-52.8
Canada	133	152	117	-14.3

Source: Greenwood's Guide to Great Lakes Shipping, 1973, 1980 and 1990.

The decline in the number of vessels in the latter period occurred in all three vessel categories -- bulk carriers, self-unloaders and tankers. It was, however, most pronounced in bulk carriers. One hundred and one bulk carriers, 62% of the total that had been in service in 1980, were removed from service in the 1980-90 period. In the same period only three self-unloading vessels were removed from service. Whereas bulk carriers accounted for about half and self-unloading vessels for about one quarter of the fleet in 1973, the situation was almost reversed in 1990. Bulk carriers were down to a third and self-unloaders had risen to nearly half of the fleet.

An examination of the data on the composition of the United States fleet in 1980 and 1990 indicates that it was the drastic decline (virtual elimination) of bulk carriers during the 1980s that was primarily responsible for the decline in the United States fleet. Of the 82 vessels removed from the United States fleet 71 were bulk carriers; only three self-unloaders and eight tankers were removed from service. Though the Canadian fleet of

bulk carriers also declined in the past decade, from 85 to 55, the Canadian decline was substantially less than the United States' decline both in absolute numbers and in percentages.

There is a reason for the substantial difference in the magnitude of the decline in the number of United States and Canadian bulk carriers; that difference has to do with the differences in the commodity mix transported by the two fleets. Grain has historically been more prominent in the Canadian than in the United States trade, where iron ore was more important. Additionally, Canadian grain was traditionally exported out of the lakes via the St. Lawrence Seaway. On the return haul the downbound grain vessel returned with an upbound load of iron ore from the iron ore ports on the north shore of the St. Lawrence River. Finally, the Canadian bulk carriers are more modern than their American counterparts, having been largely constructed after the opening of the Seaway in 1959. Thus in the 1980s the Canadian fleet of bulk carriers was more efficient than the United States fleet of bulk carriers. As a result bulkers were eliminated to a much greater extent from the United States than the Canadian fleet.

The split between United States and Canadian vessels has been substantially altered from 1973 to 1990. At the earlier date there were slightly more United States registered vessels (144) on the lakes than Canadian (133). Although the fleets of both countries increased from 1977 to 1980, the Canadian fleet grew to a greater extent (19 ships) than did the American fleet (6 ships). By 1980 the two fleets were approximately equal. Since 1980 both fleets have declined.

The number of vessels in the aggregate fleet has declined, from 277 in 1973 to 185 in 1990, but the aggregate capacity of the fleet has not; in fact it has grown very slightly. As was the case in the number of vessels, there was an increase in the aggregate capacity of the fleet from 1973 to 1980, but since 1980 there has been a significant decline. Nevertheless, in 1990 the 152 freighters (self-unloaders and bulk carriers) of the aggregate fleet had a combined capacity of 4,847,045 tons per trip; this compares to the combined capacity of 3,999,027 tons per trip in 1973 fleet (Table 9).

The only way the divergent trend of vessel numbers and aggregate capacity can be reconciled is through an increase in the average size of vessels in the fleet between 1973 and 1990. As shown in Table 9, average capacity per trip increased for bulk carriers and for self-unloading vessels. The much lower growth in average trip capacity of bulk carriers compared to self-unloaders is the principal reason for the much more pronounced decline of the former (Fig. 18).

The same data indicate that the average capacity per trip of United States self-unloaders increased more than their Canadian

TABLE 9. COMPARISON OF CARRYING CAPACITY BY VESSEL TYPE, 1973-1990

	1973	1980	1990
Total Carrying Capacity per Trip			
Bulk Carriers (Tons)			
United States	1,442,790	1,546,485	164,696
Canada	1,157,033	1,927,643	1,457,394
Subtotal	2,599,822	3,474,128	1,622,090
Self Unloaders (Tons)			
United States	795,670	1,815,727	2,120,468
Canada	603,534	995,562	1,104,852
Subtotal	1,399,205	2,811,290	3,225,320
Tankers (Barrels)			
United States	516,950	401,335	268,500
Canada	2,113,830	2,036,224	1,781,101
Subtotal	2,630,780	2,437,559	2,049,601
Total Fleet			
Bulk & Self Unloaders (ST)	3,999,027	6,285,418	4,847,410
Tankers (Bbls)	2,630,780	2,437,559	2,049,601
Average Trip Capacity			
Bulk Carriers (Tons)			
United States	18,497	19,827	23,528
Canada	18,366	22,678	26,498
Self Unloaders (Short Tons)			
United States	16,929	31,306	38,554
Canada	21,555	28,445	31,567
Tankers (Barrels)			
United States	27,208	28,667	44,750
Canada	50,329	63,632	65,967

Source: Greenwood's Guide to Great Lakes Shipping, 1973, 1980, and 1990.

1/ Capacity of bulk carriers and self-unloaders are in short (2,000 lbs.) tons.
2/ Capacity of tankers is in barrels.

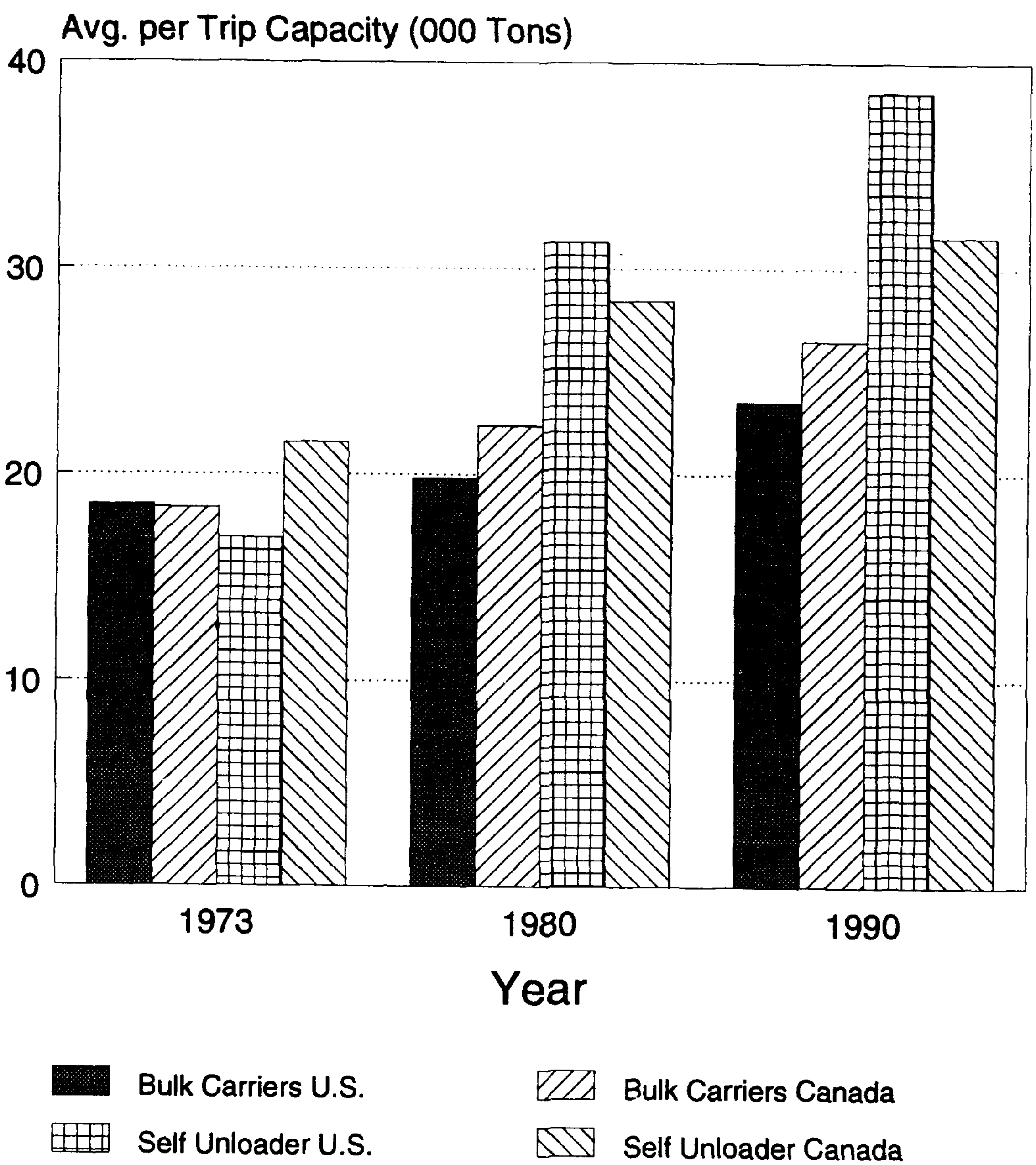


FIGURE 18. AVG. TRIP CARRYING CAPACITY OF THE GREAT LAKES FLEET: 1973, 1980 AND 1990

counterparts. The United States self-unloading fleet more than doubled its average trip capacity (from 16,929 to 38,554 tons per trip) while the Canadian self-unloading fleet increased its average trip capacity by less than 50 percent (from 21,555 to 31,567 tons per trip) (Table 9).

COMPOSITION OF THE EXISTING FLEET BY VESSEL SIZE

Ships are subject to economies of scale. For a given commodity, unit transportation costs per ton mile are less for large than for small vessels. Thus, the composition of the existing commercial navigation fleet by size of vessel is an important concern.

The Corps of Engineers has developed a comprehensive vessel size classification system for vessels operating on the Great Lakes that encompasses vessels of all sizes operating on the lakes. The categories in the classification are presented in Table 10.

The size composition of the fleet is presented in Table 11. To simplify the discussion of vessel size groups of vessels classes have been aggregated as follows:

Small Vessels - Vessel Classes 1 through 4;
Medium Vessels - Vessel Classes 5 through 8; and,
Large Vessels - Vessel Classes 9 and 10.

TABLE 10. GREAT LAKES VESSEL CLASSIFICATION BY U.S. ARMY CORPS OF ENGINEERS

Vessel Class	Vessel Length in feet
10	950 - 1,099
9	850 - 949
8	731 - 849
7	700 - 730
6	650 - 699
5	600 - 649
4	550 - 599
3	500 - 549
2	400 - 499
1	400 or less

Source: Greenwood's Guide to Great Lakes Shipping, 1973, 1980 & 1990.

TABLE 11. COMPOSITION OF THE 1990 GREAT LAKES FLEET BY VESSEL CLASS

Vessel Class	Number of Vessels U.S.	Canadian	Total
Freighters (Bulk carriers and self unloaders)			
1	0	7	7
2	0	1	1
3	1	0	1
4	1	0	1
5	23	8	31
6	7	7	14
7	6	63	69
8	11	3	14
9	1	0	1
10	13	0	13
Subtotal	63	89	152
Tankers			
1	2	16	18
2	3	12	15
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
Subtotal	5	28	33
All Vessels			
1	2	23	25
2	3	13	16
3	1	0	1
4	1	0	1
5	23	8	31
6	7	7	14
7	6	63	69
8	11	3	14
9	1	0	1
10	13	0	13
Total	68	117	185

Source: Greenwood's Guide to Great Lakes Shipping, 1990.

There are more small vessels navigating the lakes than is commonly believed. Of the total 185 vessels, 43 (23.2%) are in Classes 1 through 4 with most (41) being in Classes 1 and 2 (Table 11 and Figures 19 and 20). Most small vessels are small tankers; 33 of the 43 are tankers engaged in transporting petroleum products within the lakes. The largest number are engaged in distributing petroleum products from the refinery centers to numerous lake ports within Canada and the United States. By far, most tankers are Canadian; 28 of the 33 tankers on the lakes are of Canadian registry. In the 1990 season the number of tankers has decreased by one as one of the two larger tankers, an American vessel, was destroyed by fire in the summer of 1990.

The remaining 10 small vessels are small bulk carriers. They tend to be rather specialized vessels used to transport specific commodities to a limited number of ports. Of the ten, eight are Canadian and two American.

As there are no tankers outside of Classes 1 and 2, all medium vessels are freighters -- bulk carriers and self-unloaders. Medium size vessels are the majority of the fleet and most are Canadian; 47 are of United States Registry and 81 are of Canadian Registry.

The largest concentration of medium vessels are Class 7 vessels; 69 of the 128 medium vessels are Class 7 vessels. Not only are class 7 vessels more than half of the total number of medium vessels, Class 7 vessels constitute more than one-third (37.3%) of all vessels on the lakes. Nearly all are Canadian; of the 69 Class 7 vessels 63 are Canadian and six are American.

The reason for the large number of Class 7 vessels, and for the overwhelming Canadian registry, is that Class 7 vessels are the largest size vessels that can pass through the Welland Canal. These vessels are primarily used to ship wheat down the lakes from Thunder Bay, Ont. and on the return trip to transport iron ore from the St. Lawrence River ports to the Canadian steel mills on the Upper Lakes. Thus, Class 7 vessels account for most of the Canadian fleet. Of the total of 117 vessels in the Canadian fleet, 63 (53.8%) are Class 7 vessels. Although most of the Canadian Class 7 vessels are self-unloaders, a significant number are bulk carriers.

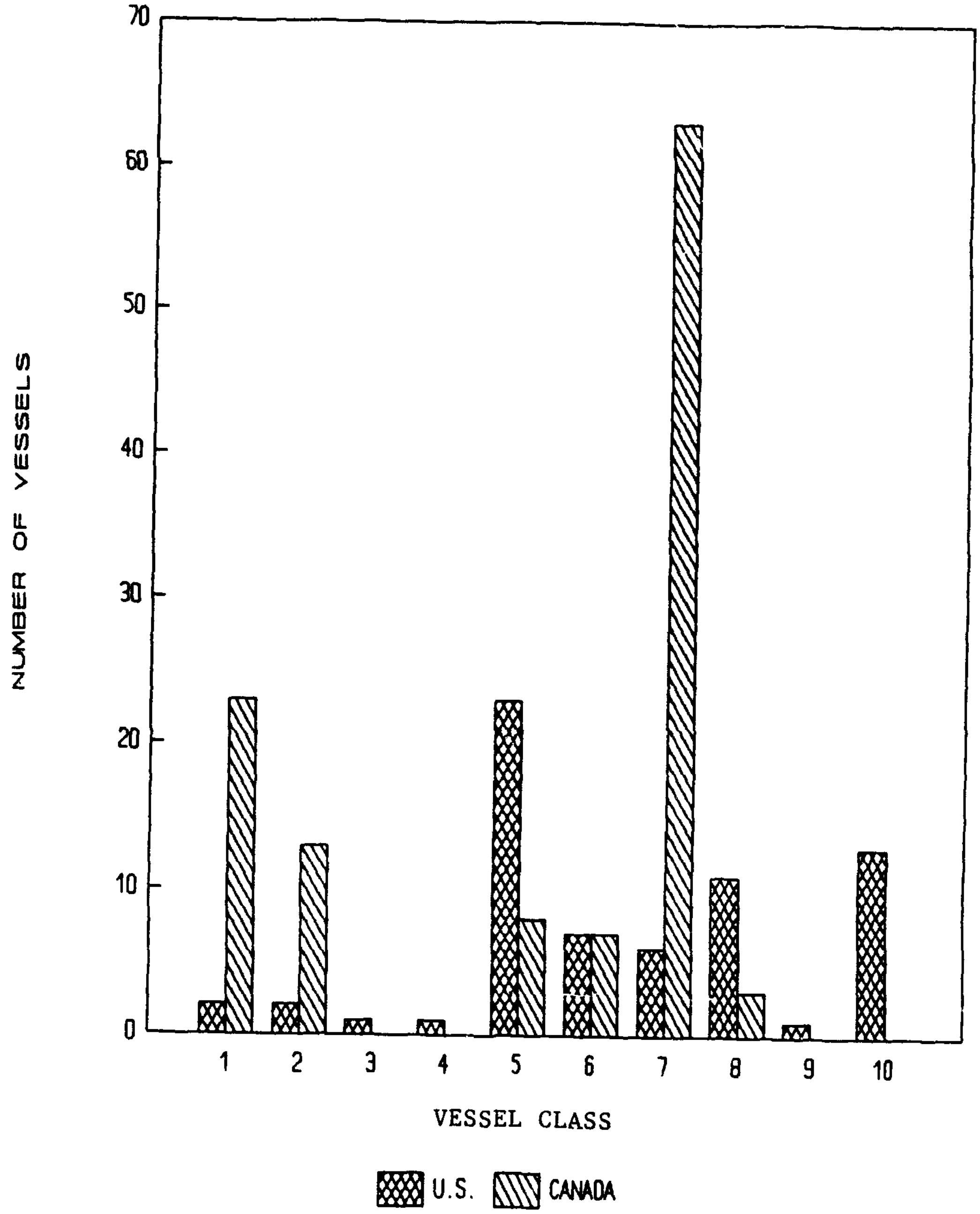


FIGURE 19. GREAT LAKES FLEET BY VESSEL CLASS, 1990

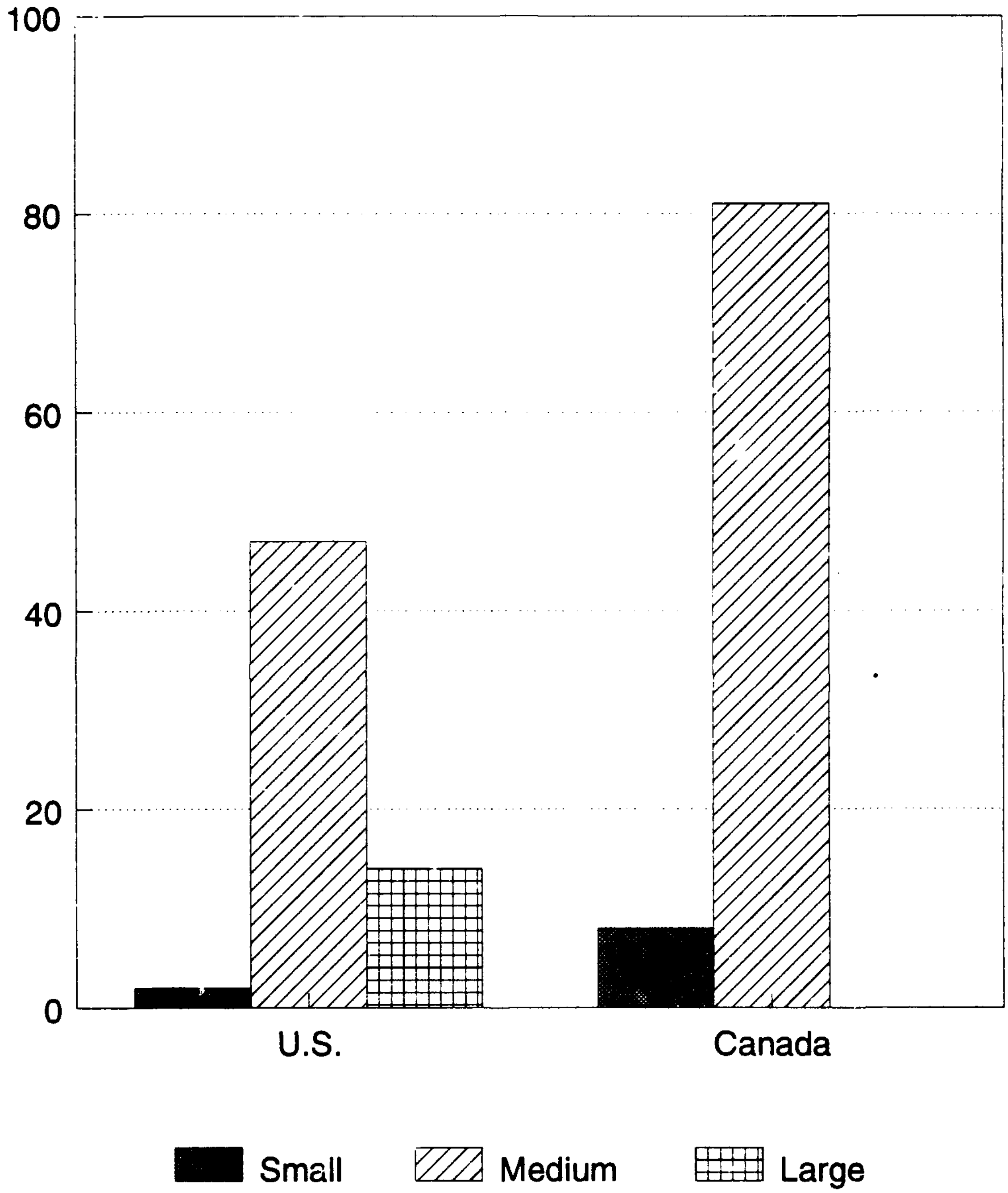


FIGURE 20. GREAT LAKES FREIGHTER FLEET BY SIZE, 1990

There are 14 large vessels (Class 9 and 10), on the Great Lakes; all 14 are under United States Registry. All are self-unloaders that principally transport iron ore from the Minnesota and Michigan ports to the integrated steel mills, and transhipment ports, situated on Lakes Michigan and Erie (including the Detroit River). The equivalent of three one thousand foot vessels are dedicated to the western coal trade between Superior, Wisconsin and the lower Great Lakes. As a group these are the largest, most efficient and most recently constructed ships operating upon the Great Lakes. The single Class 9 vessel has a capacity to transport 44,500 tons at mid-summer draft of 27.0 feet. With mid-summer drafts of 28.0 to 34.0 feet, a Class 10 vessel has the capacity to transport 60,500 to 78,850 tons. Their combined total capacity per trip at mid-summer draft, 975,000 tons, amounts to 22.5 percent of the total per trip capacity of the entire Great Lakes fleet. Given a United States fleet capacity of 2,308,825 tons per trip in 1990, these 14 vessels account for 42% percent of the per trip capacity of the American fleet. The large vessels are the backbone of the United States fleet on the Great Lakes.

EFFECT OF VESSEL SIZE ON TRANSPORTATION COSTS

Vessel size affects the cost of moving a commodity across the Great Lakes. Transportation rates are affected by numerous factors, but paramount is the cost to the carrier of providing the service. Thus vessel size has a direct and substantial bearing upon transportation rates.

This section discusses the influence that vessel size has upon "synthetic" transportation rates. A synthetic transportation rate is a theoretical rate constructed for shipment of a given commodity to/from a given origin/destination set of ports given assumed values for essential variables -- most importantly for variables affecting capital and vessel operating costs. While the resulting transportation rate is not a "real" (market determined) rate, it is consistent for vessels of different size.

A synthetic transportation rate is determined by calculating an estimated total cost to operate a vessel for one season. Total annual operating costs include an allowance for capital costs (a fixed cost) and for operating costs (a variable cost). Additionally, it is necessary to determine the total quantity of commodity that the vessel can transport in one navigation season for one port origin/destination pair. Total quantity shipped is a function of vessel draft, available draft, the vessel's immersion factor and the time required to complete one round trip (including loading and unloading time). Once total operating costs and total quantity shipped have been determined, the former is divided by the latter to produce the resulting synthetic transportation rate.

The transportation rates presented assume a fixed vessel draft that is constant for all three vessel categories. The draft used is 26 feet, which approximates the safe vessel draft at average water levels above and below the Soo Locks.

The synthetic transportation rates developed for our illustration are presented in Table 12. The effect of size on the transportation rate is substantial. Where it is estimated that the transportation rate for a Class 5 vessel at 26.0 feet draft would be $7.40 per ton, the corresponding rate for a Class 10 vessel drafting 26.0 feet would be $5.89 per ton. For the illustrative example the Class 10 transportation rate is 20% less than the Class 5 transportation rate.

If one were to transport 2,754,908 tons of iron ore from Duluth/Superior to Cleveland each year (see "Tons Moved per Season" in Table 12), the total cost to do so via a Class 5 vessels would be $20,386,319. It would require 2.29 Class 5 vessels to transport that much ore. If one were to transport the same amount in a Class 10 vessel, only one Class 10 vessel would be needed, the total cost would be $16,221,150. The difference, $4,165,169, is the savings that would accrue through use of the larger vessel.

TABLE 12. SYNTHETIC TRANSPORTATION RATE BY VESSEL CLASS FOR TRANSPORTING IRON ORE FROM DULUTH-SUPERIOR TO CLEVELAND WITH A 275 DAY SHIPPING SEASON

	Vessel Class		
	5 1/	7 1/	10 1/
Vessel Characteristics			
Midsummer Draft (feet)	27.90	30.70	28.00
Maximum Vessel Operating Draft 2/	26.00	26.00	26.00
Carrying Capacity at MSD (short tons)	26,700	39,400	66,900
TPI Factor (short tons)	106	137	265
Reduction in vessel capacity	2,417	7,727	6,360
Adjusted Carrying Capacity (short tons)	24,283	31,673	60,540
Total Round Trip Hours	132.95	135.41	145.04
Round Trips per Season	49.64	48.74	45.51
Tons Moved per Season	1,205,470	1,543,723	2,754,908
Vessel Operating Costs 3/			
Vessel Construction Cost	$34,000,000	$43,000,000	$77,000,000
Daily Variable Operating Costs	$16,255	$17,238	$22,362
Annual Fixed Operating Costs	$4,447,200	$5,624,400	$10,071,600
Yearly Variable Operating Costs	$4,470,125	$4,740,450	$6,149,550
Fixed and Variable Operating Costs per Season	$8,917,325	$10,364,850	$16,221,150
Transportation Rate per Ton	$7.40	$6.71	$5.89

1/ The vessel characteristics are for specific vessels in the appropriate class:

Vessel Class	Vessel Name
5	Fred R. White, Jr.
7	H. Lee White
10	George Stinson

2/ For purposes of analysis, maximum vessel operating draft has been restricted to 26 feet.

3/ Vessel operating costs are the 1990 operating costs provided by MARAD.

CHAPTER 5

COMMODITY FLOWS

The composition of Great Lakes commerce is not unlike that of waterborne commerce elsewhere. Worldwide, waterborne trade is principally in bulk commodities such as oil, coal, grain, ores and minerals. Measured by weight, they represent about 85 percent of total trade. A wide variety of goods and materials that are handled as individual units account for the other 15 percent by weight, but a much higher share by value. The trade terms for those cargoes are general cargo (packaged goods, increasingly shipped in marine containers), and neo-bulks (unpackaged things such as steel shapes and coils, and automobiles and timber at tidewater ports).

U.S. Great Lakes ports are estimated to handle about five million tons annually of neo-bulk and general cargoes. Virtually all of those cargoes are part of the U.S. direct overseas trade via the Seaway. They only account for about five percent of total U.S. Lakes commerce because of the availability of alternate transportation modes for domestic movements and trade with Canada, and because ocean transportation cost competitiveness is limited by the St. Lawrence Seaway lock size constraints. As a result, bulk cargoes are the backbone of U.S. Great Lakes commerce for domestic movements and trade with Canada, and because bulk commodities can be transshipped economically on the lower St. Lawrence, for Lakes-overseas trade.

BULK COMMODITIES

Data on the shipments of the major bulk commodities upon the Great Lakes for the 1979-90 period are presented in Table 13. The same data reduced to percentage shares are shown in Table 14. The data in Table 13 has been graphed and is presented as Figure 21. Maps of principal shipping (loading) and receiving ports on the lakes are presented in the discussion of ports in Chapter 6.

Data Sources

Data on receipts -- movements of materials into a port of destination -- have been obtained from the Corps of Engineers' Waterborne Commerce of the United States, Part 3 Waterways and Harbors, Great Lakes. These annual reports are commonly referred to as the "Gray Books". Hereafter, the term "Gray Book" will be used to refer to Part 3 of each year's annual report.

The data on shipments -- movements of materials from a port of origin -- have been obtained from the Annual Reports of the uLake Carriers' Association.

TABLE 13. GREAT LAKES BULK COMMERCE BY COMMODITY, 1979 - 1990
(TONS)

Year	Iron Ore	Coal	Stone	Cement	Potash	Petroleum	Grain	Total
1990	68,877,140	37,993,533	33,746,820	4,501,904	1,497,167	12,895,665	15,[illegible],535	175,352,764
1989	66,710,045	39,469,501	35,075,213	4,479,295	1,586,531	11,104,592	15,007,810	173,432,987
1988	68,306,193	40,521,133	35,501,484	4,162,954	1,576,347	11,972,621	19,101,760	181,142,492
1987	61,702,505	37,731,742	33,163,539	3,805,799	1,702,174	11,521,158	22,338,366	171,965,283
1986	51,017,057	36,266,922	27,225,922	4,082,975	1,629,493	11,987,025	20,155,541	152,364,935
1985	58,431,773	36,334,525	24,992,777	3,398,789	1,857,561	12,883,941	20,055,902	157,955,268
1984	64,136,610	43,134,292	23,156,860	3,408,621	2,032,470	14,961,876	28,152,658	178,983,387
1983	58,335,209	36,578,742	18,418,662	3,284,106	1,599,778	14,964,244	28,846,648	162,027,389
1982	43,134,081	36,759,518	15,076,245	3,021,696	1,813,142	14,351,287	28,283,271	142,437,240
1981	83,893,203	39,096,577	24,586,743	3,706,778	1,593,556	15,667,667	28,235,436	196,779,960
1980	81,723,442	41,306,125	28,011,339	4,213,053	891,171	19,028,857	31,509,534	206,683,521
1979	103,100,405	45,833,297	36,976,066	5,393,839	477,699	19,581,382	28,881,619	240,244,307

Source: Annual Reports, Lake Carriers Association

TABLE 14. PERCENT DISTRIBUTION BY COMMODITY FOR GREAT LAKES BULK COMMERCE, 1979 - 1990

Year	Iron Ore	Coal	Stone	Cement	Potash	Petroleum	Grain	Total
1990	39.3	21.7	19.2	2.6	0.9	7.4	9.0	100.0
1989	38.5	22.8	20.2	2.6	0.9	6.4	8.7	100.0
1988	37.7	22.4	19.6	2.3	0.9	6.6	10.5	100.0
1987	35.9	21.9	19.3	2.2	1.0	6.7	13.0	100.0
1986	33.5	23.8	17.9	2.7	1.1	7.9	13.2	100.0
1985	37.0	23.0	15.8	2.2	1.2	8.2	12.7	100.0
1984	35.8	24.1	12.9	1.9	1.1	8.4	15.7	100.0
1983	36.0	22.6	11.4	2.0	1.0	9.2	17.8	100.0
1982	30.3	25.8	10.6	2.1	1.3	10.1	19.9	100.0
1981	42.6	19.9	12.5	1.9	0.8	8.0	14.3	100.0
1980	39.5	20.0	13.6	2.0	0.4	9.2	15.2	100.0
1979	42.9	19.1	15.4	2.2	0.2	8.2	12.0	100.0

Source: Annual Reports, Lake Carriers Association

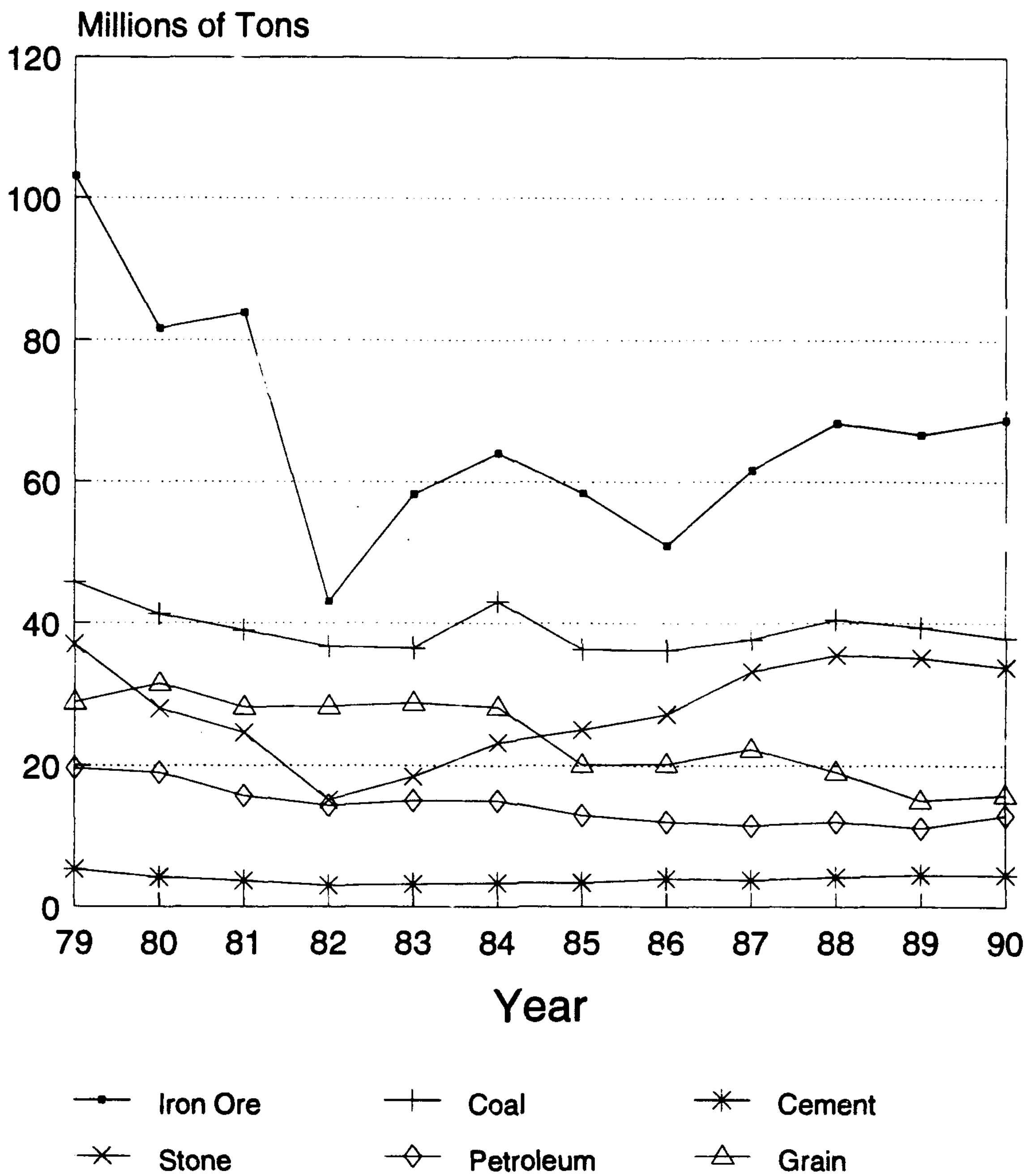


FIGURE 21. GREAT LAKES BULK COMMERCE BY COMMODITY, 1979-1990

Bulk Commodities: An Overview

Iron ore (in the form of pellets) has been, and remains, the dominant commodity transported on the Great Lakes. In the period of analysis (1979-90) it accounted for as much as 42% and as little as 30% of all bulk commodities shipped across the lakes.

Lesser, but still significant, quantities of coal, stone, grain (including soybeans) and petroleum products are transported across the lakes. Coal ranks second to iron ore; its share of bulk shipments has varied from 19% to 26% of all bulk commodities. Currently stone is the third leading bulk commodity followed by grain. In 1990, stone accounted for 19% and grain accounted for nine percent of bulk shipments. However, the volume of grain, and grain's share of total bulk shipments, has fluctuated widely. In 1982 grain's share (20%) exceeded that of limestone (11%). Petroleum products rank fifth; its share has varied from 6% to 10% of all bulk shipments.

Looking at the tonnage data in Table 13, one notes a decline in the tons of bulk commodities transported on the lakes. The decline from 240.2 million tons in 1979 to 142.4 million tons in 1982 is very pronounced; this was a decline of 39% in three years. Between 1983 and 1990 total tonnages fluctuated between 160 and 180 million tons.

With iron ore being the dominant commodity shipped on the lakes, it is clear that the decline in iron ore shipments played a significant role in affecting the decline in total tons shipped. Iron ore shipments declined from 103.0 million tons in 1979 to only 43.0 tons in 1982, a decline of 58% in three years.

Iron ore shipments were not the only commodity shipments that declined substantially from 1979 to 1982; shipments of coal, stone, cement and petroleum products also declined substantially. For each of these the decline was: coal - 20%, stone - 59%; cement - 44% and petroleum products - 27%. The 1979-82 interval was a difficult time for the economy of the U.S., and in particular, for the Great Lakes Region. These were the years of the "decline of the Rust Belt" and "growth of the Sun Belt".

The national and Great Lakes regional economy began to recover from the 1979-1982 recession in 1983. The recovery continued for seven consecutive years; it was the longest uninterrupted economic recovery in the history of the nation. In the 1983-90 interval, shipments of bulk commodities transported across the lakes should have increased. They did, but the increase in shipments of bulk commodities on the lakes peaked in 1988; 1989 and 1990 shipments were below the 1988 levels.

Iron Ore

There are two spatial flows of iron ore on the Great Lakes. The first, and by far the most important, is the shipment of pelletized iron ore from the "Head of the Lakes" (the western end of Lake Superior) and from the western part of the Upper Peninsula of Michigan "down" the lakes. This is a flow from five ports on Lake Superior (Duluth-Superior, Two Harbors, Silver Bay, Taconite and Marquette) and one port on Lake Michigan (Escanaba). Until 1987, it also included the shipment of some Canadian ore from Thunder Bay; however, this flow ceased in 1987. At present this is entirely a domestic, United States commodity movement.

The second flow is "up" the Great Lakes from three ports located on the north shore of the Gulf of St. Lawrence -- Point Noire, Port Cartier and Sept Iles. The ore is mined and processed at mines situated a substantial distance to the north, along the Quebec Labrador border, from which it is transported by rail to the above mentioned ports. The ore is then loaded into Seaway-size vessels and transported through the St. Lawrence Seaway into the Great Lakes, mainly to Canadian steel mills located at Hamilton (on Lake Ontario) and Nanticoke (located on the north shore of Lake Erie). A modest amount, 4.4 million tons in 1989, is transported to U.S. steel mills.

Data on iron ore shipments by port of origin across the Great Lakes, and also, for the three Canadian Ports along the north shore of the Gulf of St. Lawrence are presented in Table 15. Most of the iron ore (82.6% in 1990) is shipped from U.S. ports. Duluth-Superior is the dominant iron-ore shipping port on the Lakes; in 1990 it originated 30.3% of the total. Two Harbors, Silver Bay (whose taconite plant had been closed in 1988 and 1989), Marquette and Escanaba account for the remainder of U.S. shipments. Shipments from Escanaba have declined substantially in the 1979-90 period; they went from 13.2 million tons in 1979 to 5.5 million tons in 1990.

The destinations (harbors of receipt) of iron ore shipments from the "Head of the Lakes" are the integrated steel mills situated along the United States shore of Lakes Michigan and Erie and along the Detroit River. Shipments are also destined for some inland mills served by ports on those lakes. Iron ore is principally destined for Lake Erie ports (Lorain, Cleveland, Toledo, Ashtabula and Conneaut) and Lake Michigan Ports (Indiana Harbor, Gary, Burns Waterway Harbor and Chicago). Significant amounts are also shipped to the Port of Detroit on the Detroit River.

TABLE 15 : GREAT LAKES IRON ORE SHIPMENTS, 1979-1990
(1000 TONS)

	LAKE SUPERIOR							LAKE MICHIGAN	LAKE HURRON	CANADIAN PORTS				
YEAR	DULUTH SUPERIOR	TWO HARBORS	SILVER BAY	TACONITE HARBOR	MARQUETTE	THUNDER BAY	SUB TOTAL	ESCANABA	LITTLE CURRENT	POINT NOIRE	PORT CARTIER	SEPT ISLES	Sub Total	Total
1990	20,896	12,962	2,463	9,695	5,517	0	51,434	5,498	0	5,528	4,039	2,378	11,945	68,877
1989	20,349	10,475	0	9,057	10,049	0	49,931	6,329	0	5,635	3,116	1,699	10,450	66,710
1988	21,186	12,105	0	8,645	8,878	0	50,814	7,341	0	5,314	1,847	2,991	10,151	68,307
1987	21,177	7,976	205	8,847	7,910	0	46,115	6,649	0	4,664	1,412	2,862	8,937	61,703
1986	15,717	6,894	1,624	6,112	4,002	569	34,918	8,264	0	3,852	918	3,065	7,835	51,017
1985	16,396	9,766	3,837	5,636	5,680	532	41,847	8,271	0	4,918	1,162	2,234	8,314	58,432
1984	21,183	7,622	4,064	3,907	4,992	1,063	42,731	9,651	243	5,612	1,632	4,266	11,512	64,137
1983	17,055	9,337	3,043	4,333	3,931	1,565	39,263	8,306	193	5,230	786	4,557	10,573	58,335
1982	15,613	5,016	2,379	4,059	2,166	891	30,123	5,958	67	2,775	1,261	2,951	6,986	43,135
1981	26,588	11,195	7,113	8,561	5,983	1,358	60,798	9,792	17	5,474	2,334	5,478	13,286	83,893
1980	26,218	11,211	4,927	6,829	6,408	2,975	58,567	11,257	0	4,837	1,961	5,101	11,899	81,723
1979	32,159	12,459	9,259	10,803	5,972	4,257	74,709	13,234	255	5,767	3,007	6,129	14,902	103,100

SOURCE: LAKE CARRIERS ASSOCIATION, ANNUAL REPORTS 1979-1990.

It should be noted that there is significant "double counting" of iron ore receipts received at Lorain and Cleveland, Ohio. The ore brought into Lorain is transported in Class 10 vessels. At Lorain the ore is reloaded into smaller, Class V vessels that can navigate the tight channel of the Cuyahoga River in Cleveland. Thus, much of the iron ore received at Lorain is also received at Cleveland. However, as there is a steel mill located at Lorain and some of the iron ore transported to Cleveland is shipped by rail to inland steel mills, it is difficult to sort out the magnitude of the double counting without obtaining and disclosing detailed industry data. It is estimated that five to six million tons of the Lorain ore are double counted.

Of the harbors listed above as receiving significant amounts of iron ore, three (Toledo, Ashtabula and Conneaut) do not possess steel mills. The iron ore received at these ports is shipped by rail to mills located at inland locations. As mentioned, some of the iron ore shipped to Cleveland is also railed to inland locations.

Coal

Historically coal has been the second most prominent commodity transported on the Great Lakes based upon tons shipped (Table 13). As is true of all bulk commodities shipped on the lakes, tonnages have fluctuated considerably from year to year. In the 1979 to 1990 period the largest volume of coal (45.8 million tons) was shipped in 1979 and the smallest volume (36.3 million tons) was shipped in 1986. Coal's share of the seven leading bulk commodities shipped on the lakes was at a maximum (25.8%) in 1982 and its share was a minimum (19.1%) when its tonnage was the most (1979) (Table 14).

There are two principal uses for coal: 1) as an input in the production of coke -- which is an input into blast furnaces in the production of steel; and 2) generation of steam to produce electricity in thermal electric plants. The two uses require different types of coal. Coal used to produce coke is coking coal and coal used to generate steam to turn turbines in a thermal electric plant is steam coal. Coking coal is necessarily bituminous coal; steam coal may or may not be bituminous coal.

Most if not all of the coal transported across the Great Lakes is steam coal. While on a short-term basis there is some fluctuation in the demand for electricity and thus for steam coal, the trend has been for production of more electricity and more utilization of steam coal.

There are two major spatial flows of coal shipments across the Great Lakes. Historically the major flow has been railroad

shipments from the Appalachian and Mid Western states of the United States to Lake Erie ports, and to a much lesser extent, to the Port of Chicago on Lake Michigan. At these ports the coal is loaded onto Great Lakes freighters and transported up and down the lakes. This is known as the flow of Eastern coal.

A relatively recent innovation is the rail shipment of coal from western states, principally Wyoming and Montana, to Duluth-Superior where the coal is loaded into Great Lakes freighters and shipped down the lakes. There is a corresponding but much smaller flow of lignite (a low grade coal) shipped by rail from southeastern Saskatchewan to the Canadian port of Thunder Bay, where the coal is loaded into Great Lakes freighters and shipped to Ontario. This is known as the flow of Western Coal. In the 1979-90 period shipments of Western coal across the lakes have grown, while in general terms, shipments of Eastern coal have been declining (Table 16 and Figure 22). Percentages are shown in Table 17.

Eastern coal is steam coal destined for power electric plants located along the shores of the Great Lakes, both in the United States and in Canada. At present it does not appear that any coking coal is transported by water to steel mills situated along the shores of the Great Lakes; it appears that all coking coal transported to these steel mills is transported by rail.

In some years, but not on a regular basis, U.S. Eastern coal has been shipped to Europe via the St. Lawrence Seaway. When that is done, the coal is shipped through the Seaway on a Seaway-size vessel (730 feet) and the coal is unloaded into an ocean going vessel (a "salty") somewhere in the protected waters of the Gulf of St. Lawrence or the Atlantic Ocean off the Maritime Provinces. The ocean going vessel, being larger, can transport the coal across the Atlantic at a lower cost per ton than could the Seaway vessel.

Western coal has a much lower sulfur content than does Eastern coal. The sulfur content of Western coal averages less than 0.5%. The sulfur content of Eastern coal varies considerably; some has less than 1.0% sulfur (this is termed Low sulfur Eastern coal) but most average more than 1.0% sulfur (medium sulfur and high sulfur Eastern coal). However, Western coal has a significantly lower energy content than Eastern coal. Whereas good quality Eastern coal can produce 13,000 BTUs per pound of coal, Western coal averages between 8,400 to 9,500 BTUs per pound; lignite produces even less energy.

TABLE 16. TONS OF EASTERN AND WESTERN COAL MOVED ON THE GREAT LAKES BY SHIPPING PORTS, 1979 - 1990

	EASTERN COAL							WESTERN COAL			
	Lake Erie						Lake Michigan	Lake Superior			
Year	Toledo	Sandusky	Ashtabula	Conneaut	Erie	Sub Total	South Chicago	Superior	Thunder Bay	Sub Total	Total
19[illegible]	7,281,256	4,328,596	4,974,709	5,602,627	-	22,187,187	533,150	12,267,862	3,005,334	15,273,196	37,993,533
	7,165,733	4,230,471	4,961,567	6,461,257	-	22,819,028	8862,561	11,775,150	4,012,762	15,787,912	39,469,501
1988	7,839,579	4,545,220	6,267,506	7,655,479	-	26,307,784	435,661	10,079,146	3,[illegible]98,542	13,777,688	40,521,133
1987	8,416,114	3,204,886	6,080,197	5,252,960	-	22,954,157	400,503	11,157,326	3,219,756	14,377,082	37,731,742
1986	10,672,936	3,934,878	3,706,092	6,724,957	-	25,038,863	542,278	8,180,871	2,504,910	10,685,781	36,268,922
1985	10,520,184	4,541,017	4,524,780	6,760,199	-	26,346,180	823,319	6,990,885	2,174,141	9,165,026	36,334,528
1984	12,078,955	4,793,871	5,493,617	10,003,458	-	32,369 901	1,144,809	6,677,350	2,942,232	9,619,582	43,134,292
1983	11,154,847	4,271,048	4,907,021	7,093,232	30,404	27,458,552	1,238,052	5,718,900	2,165,238	7,884,136	36,578,742
1982	8,805,930	4,986,337	5,019,638	10,135,225	-	28,947,130	1,726,797	3,790,273	2,295,318	6,085,591	36,759,518
1981	12,159,605	5,620,341	4,908,725	8,217,812	-	30,906,483	1,647,166	N.A.	N.A.	6,542,928	39,096,577
1980	12,717,172	6,222,109	5,412,048	7,843,709	-	32,195,038	2,266,237	N.A.	N.A.	6,844,850	41,306,125
1979	14,563,461	5,714,196	6,439,871	10,326,469	-	37,043,997	2,391,833	N.A.	N.A.	6,397,467	45,833,297

Source: 1990, 1985, 1983, 1981 and 1979 Annual Reports, Lake Carriers Association

TABLE 17. PERCENTAGES OF EASTERN AND WESTERN COAL MOVED ON THE GREAT LAKES BY SHIPPING PORTS, 1979 - 1990

	EASTERN COAL							WESTERN COAL			
	Lake Erie						Lake Michigan	Lake Superior			
Year	Toledo	Sandusky	Ashtabula	Conneaut	Erie	Sub Total	South Chicago	Superior	Thunder Bay	Sub Total	Total
1990	19.16	11.39	13.09	14.75	-	58.40	1.40	32.29	7.91	40.20	100.00
1989	18.16	10.72	12.57	16.37	-	57.81	2.19	29.83	10.17	40.00	100.00
1988	19.35	11.22	15.47	18.89	-	64.92	1.08	24.87	9.13	34.00	100.00
1987	22.31	8.49	16.11	13.92	-	60.84	1.06	29.57	8.53	38.10	100.00
1986	29.43	10.85	10.22	18.54	-	69.04	1.50	22.56	6.91	29.46	100.00
1985	38.95	12.50	12.45	18.61	-	72.51	2.27	19.24	5.98	25.22	100.00
1984	28.00	11.11	12.74	23.19	-	75.04	2.65	15.48	6.82	22.30	100.00
1983	30.50	11.68	13.41	19.39	0.08	75.06	3.38	15.63	5.92	21.55	100.00
1982	23.96	13.56	13.66	27.57	-	78.75	4.70	10.31	6.24	16.56	100.00
1981	31.10	14.38	12.56	21.02	-	79.05	4.21	N.A.	N.A.	16.74	100.00
1980	30.79	15.06	13.10	18.99	-	77.94	5.49	N.A.	N.A.	16.57	100.00
1979	31.77	12.47	14.05	22.53	-	80.82	5.22	N.A.	N.A.	13.96	100.00

Source: 1990, 1985, 1983, 1981 and 1979 Annual Reports, Lake Carriers Association

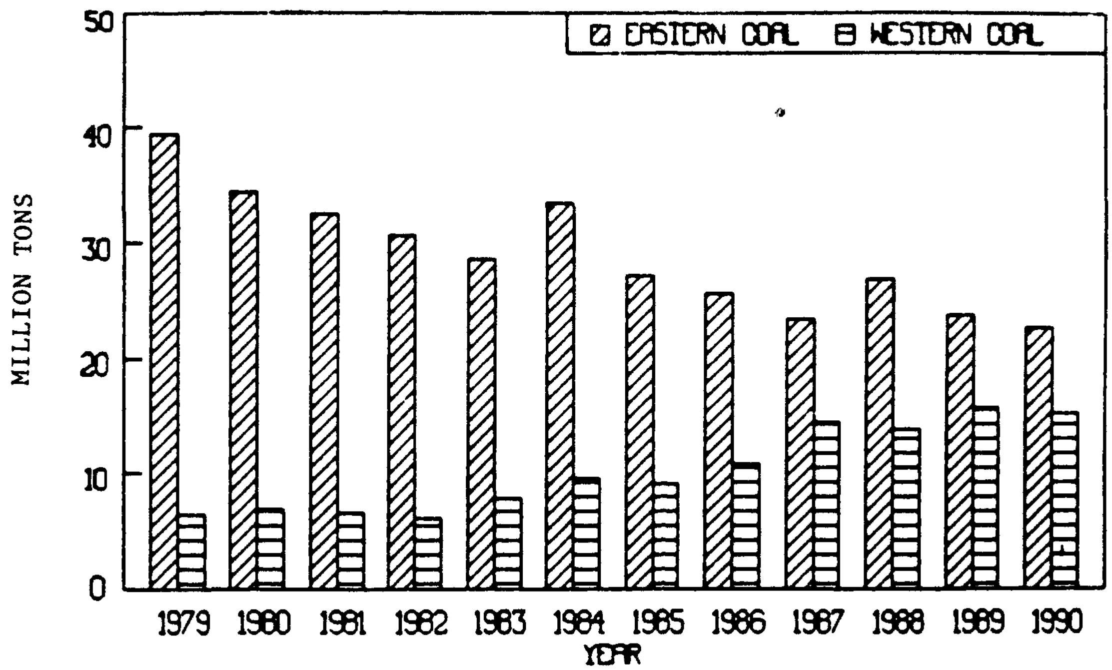


FIGURE 22. EASTERN VERSUS WESTERN COAL SHIPPED ON THE GREAT LAKES, 1979-1990

Western coal has been capturing some of the traditional electric utility market held by Eastern coal. This trend will continue. How far it will continue is another question. It is a question that every utility, as well as others, is currently attempting to answer. At this time, the answer to the question is unclear.

Another factor affecting the quantity of coal to be transported across the Great Lakes in the future is the question of effectiveness of rail competition. In recent years the railroads have been very aggressive and very effective in competing with Great Lakes shippers for what traditionally has been waterborne traffic. Detroit Edison, part owner of Western Energy, the originator of virtually all U.S. coal shipments from Duluth/Superior, already ships coal by rail from the Powder River Basin to two of its electric power plants in southeastern Michigan. Currently, Western coal is being railed into Green Bay and Milwaukee in Wisconsin and reportedly, some has been shipped by rail into Ashtabula, Ohio. The last is particularly notable as Ashtabula is a traditional coal shipment port, shipping Eastern coal along the Great Lakes.

To what extent will the railroads capture the projected increased shipment of Western Coal into the Great Lakes Region? At the moment it is difficult to say. The Great Lakes carriers will strive to maintain their market share. They have the advantage of long-term contracts and of a largely depreciated fleet. They also have an advantage because most water supplied electric utilities do not have adequate rail facilities nor the space to install adequate rail facilities needed to handle the unit trains that enable the railroads to provide transportation rates competitive with waterborne transportation of coal.

The principal disadvantage the Great Lakes carriers face in transporting coal is their inability to implement further economies of scale in transporting any commodity, including coal. The Poe Lock limits the size of vessels that can navigate from Lake Superior into Lakes Michigan and Huron; the largest size vessel that can proceed through the Poe Lock is a 1,000 foot, Class 10 vessel. Even if a larger lock was built, it does not necessarily follow that larger vessels would be constructed to use the new lock. It appears that rail competition may have reduced waterborne transportation rates that the waterborne shippers can charge to the point where a fleet operator could not justify the expenditure of capital for a fleet of new, larger vessels.

The railroads are not unconstrained. They have been successful in the past decade in implementing improvements in their systems that have substantially increased their productivity, thus reducing their costs and permitting them to compete effectively with waterborne transportation of coal. But

the western railroads may have exhausted their relatively inexpensive improvements. Further improvements to increase productivity may be much more expensive and may not be justified by the potential return from the coal traffic. As long as water transportation remains a viable option, the waterborne transportation rates impact the rail rates and act as a cap to what the railroads can charge.

What is the conclusion? Shipments of Western coal will continue to rise and shipments of Eastern Coal will continue to decline. Eastern coal will increasingly be displaced from its traditional electric utility market, but it will not be eliminated from that market. Shipments of low sulfur Eastern coal (sulfur content below 1.0%) probably will increase, but whether that increase can offset the decline in the quantity of medium and high sulfur Eastern coal is problematical.

Grain

The volume of grain (including soybeans) shipped across the Great Lakes has been declining since 1979. While the volume of grain shipments may have increased slightly from one year to another, the overall trend is down. In 1980 nearly 32.0 million tons of grain were shipped across the lakes. In 1989 and 1990 the volume ranged between 15.0 to 16.0 million tons (Table 13). Correspondingly, grain's share of the seven major bulk commodities declined from 19.9% in 1982 to 8.6% in 1989 (Table 14). Since 1985, more limestone has been transported on the lakes than grain. Thus, in the recent past grain has slipped from third to fourth in the rank of bulk commodities transported on the lakes.

The data on port of origin of grain shipments is incomplete. A complete set of data for United States and Canadian grain shipments is available only for the years 1979 to 1981 and for 1987 to 1990. Those data are presented in Table 18. The same data reduced to percentages are presented as Table 19. Data on the composition of grain shipments by port of origin are presented in Table 20.

Quite clearly the pattern of grain shipments on the Great Lakes in the 1987-90 period is substantially different from that in the earlier 1979-81 period. Not only was the amount of grain shipped across the lakes less in the more recent period, but the split between Canadian and U.S. grain has reversed. In the earlier period most grain transported on the lakes was U.S. grain; in the later period most grain transported on the lakes was Canadian grain. While Canadian grain shipments declined over the two time periods, it is the drastic decline of U.S. grain shipments that has caused the reversal in country of origin (Tables 18, 19 and 20).

TABLE 18 : GRAIN SHIPMENTS ON THE GREAT LAKES BY PORT OF ORIGIN, SELECTED YEARS 1979-1990
(1000 NET TONS)

	LAKE SUPERIOR			LAKE MICHIGAN			LAKE HURON	SAINT CLAIR RIVER	LAKE ERIE					
YEAR	DULUTH SUPERIOR	THUNDER BAY	Sub Total	MILWALKE	CHICAGO	Sub Total	SAGINAW	SARNIA	TOLEDO	HURON	Sub Total	Total	U.S. GRAIN	CANADIAN GRAIN
1990	4,222	9,725	13,947	344	65	409	0	483	999	0	999	15,838	5,632	10,209
1989	4,829	6,832	11,661	392	478	870	0	433	2,016	29	2,045	15,009	7,743	7,265
1988	4,903	11,713	16,616	556	410	966	0	485	1,022	13	1,035	19,102	6,904	12,198
1987	3,483	15,420	18,903	508	552	1,060	0	470	1,814	92	1,906	22,339	6,449	15,889
1981	7,789	13,676	21,465	1,008	873	1,881	261	287	4,027	360	4,387	28,281	14,317	13,963
1980	9,567	14,564	24,131	1,364	852	2,216	310	0	4,767	446	5,213	31,870	17,305	14,564
1979	7,316	12,493	19,809	1,646	2,594	4,240	430	0	4,223	180	4,403	28,882	16,389	12,493

SOURCE : LAKE CARRIERS ASSOCIATION, ANNUAL REPORTS FOR SPECIFIED YEARS.

TABLE 19 : PERCENT DISTRIBUTION OF GRAIN SHIPMENTS ON THE GREAT LAKES BY PORT OF ORIGIN, SELECTED YEARS 1979-1990

(PERCENT)

	LAKE SUPERIOR			LAKE MICHIGAN			LAKE HURON	SAINT CLAIR RIVER	LAKE ERIE					
YEAR	DULUTH SUPERIOR	THUNDER BAY	Sub Total	MILWALKE	CHICAGO	Sub Total	SAGINAW	SARNIA	TOLEDO	HURON	Sub Total	Total	U.S. GRAIN	CANADIAN GRAIN
1990	26.7	61.4	88.1	2.2	0.4	2.6	0.0	3.1	6.3	0.0	6.3	100.0	35.6	64.4
1989	32.2	45.5	77.7	2.6	3.2	5.8	0.0	2.9	13.4	0.2	13.6	100.0	51.6	48.4
1988	25.7	61.3	87.0	2.9	2.1	5.0	0.0	2.5	5.4	0.1	5.5	100.0	36.1	63.9
1987	15.6	69.0	84.6	2.3	2.5	4.8	0.0	2.1	8.1	0.4	8.5	100.0	28.9	71.1
1981	27.5	48.4	75.9	3.6	3.1	6.7	0.9	1.0	14.2	1.3	15.5	100.0	50.6	49.4
1980	30.0	45.7	75.7	4.3	2.7	7.0	1.0	0.0	15.0	1.4	16.4	100.0	54.3	45.4
1979	25.3	43.3	68.6	5.7	9.0	14.7	1.5	0.0	14.6	0.6	15.2	100.0	56.7	43.3

SOURCE : LAKE CARRIERS ASSOCIATION, ANNUAL REPORTS FOR SPECIFIED YEARS.

TABLE 20. COMPOSITION OF GRAIN MOVEMENTS BY COMMODITY, 1987 - 1990
(Tons)

COMMODITY	1987	1988	1989	1990	FOUR YEAR AVERAGE	PERCENT OF TOTAL
U.S. AND CANADA						
Wheat	15,495,134	12,774,007	9,434,128	11,581,903	12,321,293	68.18
Corn	2,181,804	2,796,071	2,515,353	1,143,887	2,159,279	11.95
Barley	2,246,179	1,905,836	1,473,758	1,748,066	1,843,460	10.20
Flax	455,480	276,573	222,609	178,357	283,255	1.57
Rapeseed	284,634	300,924	122,084	11,984	179,907	1.00
Oats	142,105	133,961	357,032	323,871	239,242	1.32
Soybeans	1,354,312	877,857	837,768	346,070	854,002	4.73
Sunflower seeds	138,221	16,548	0	0	38,692	0.21
Millet	0	0	21,123	36,846	14,492	0.08
Canolaseed	0	0	0	450,645	112,661	0.62
Rye	40,227	19,983	23,955	18,906	25,768	0.14
Screenings	0	0	0	0	0	0.00
TOTAL ALL COMMODITIES	22,338,096	19,101,760	15,007,810	15,840,535	18,072,050	100.00

COMMODITY	1987	1988	1989	1990	FOUR YEAR AVERAGE	PERCENT BY COUNTRY
UNITED STATES						
Wheat	2,537,337	2,625,182	3,452,663	3,058,563	2,918,436	43.68
Corn	1,997,706	2,692,579	2,442,306	1,005,186	2,034,444	30.45
Barley	537,463	802,456	1,050,649	1,199,242	897,453	13.43
Flax	0	0	0	0	0	0.00
Rapeseed	0	0	0	0	0	0.00
Oats	0	0	0	0	0	0.00
Soybeans	1,232,719	756,098	767,606	309,972	766,599	11.47
Sunflower seeds	138,221	16,548	0	0	38,692	0.58
Millet	0	0	21,123	36,846	14,492	0.22
Canola seed	0	0	0	22,130	5,533	0.08
Rye	5,470	11,275	8,493	0	6,310	0.09
	0	0	0	0	0	0.00
SUBTOTAL	6,448,916	6,904,138	7,742,840	5,631,939	6,681,958	100.00
CANADA						
Wheat	12,957,797	10,148,825	5,981,465	8,523,340	9,402,857	82.55
Corn	184,098	103,492	73,047	138,701	124,835	1.10
Barley	1,708,716	1,103,380	423,109	548,824	946,007	8.31
Flax	455,480	276,573	222,609	178,357	283,255	2.49
Rapeseed	284,634	300,924	122,084	11,984	179,907	1.58
Oats	142,105	133,961	357,032	323,871	239,242	2.10
Soybeans	121,593	121,759	70,162	36,098	87,403	0.77
Sunflower seeds	0	0	0	0	0	0.00
Millet	0	0	0	0	0	0.00
Canola seed	0	0	0	428,515	107,129	0.94
Rye	34,757	8,708	15,462	18,906	19,458	0.17
Screenings	0	0	0	0	0	0.00
SUBTOTAL	15,889,180	12,197,622	7,264,970	10,208,596	11,390,092	100.00

Source: 1987 Through 1990, Annual Reports, Lake Carriers Association.

There are several reasons for the drastic decline in U.S. grain shipments. Some of the reasons are the result of domestic economic issues and some are the result of international economic issues. In any case, the explanation is beyond the scope of this report.

A basic difference between Canadian and U.S. grain exports lies in the fact that virtually all Canadian grain shipments on the Great Lakes are shipped from one port, the Port of Thunder Bay, Ontario; only minor amounts are shipped from Sarnia, Ontario. U.S. grain shipments on the other hand originate in several ports though the dominant port is Duluth-Superior on Lake Superior. Chicago and Milwaukee on Lake Michigan and Toledo and Huron on Lake Erie are of lesser importance.

Another difference is that Canadian grain shipments are predominantly shipments of wheat; barley is a distant second. In the U.S. wheat is the leading commodity but substantial amounts of corn, soybeans and barley are also shipped (Table 20).

The concentration of grain shipments in Canada at one port (Thunder Bay) with the concentration upon shipments of wheat, and the more diverse pattern of shipments of substantial volumes of four crops from several ports in the United States, is due to the agricultural geography of the two nations. The dominant agricultural region in Canada is the Spring Wheat Belt in the Prairie Provinces of Manitoba, Saskatchewan, and to a lesser extent Alberta. In the U.S. there is no single agricultural region that is as dominant as the Canadian Prairie though two regions -- the Mid Western Corn Belt and the two wheat belts (Winter and Spring Wheat) of the Great Plains -- are quite prominent. In Canada the Great Lakes provide an outlet to the wheat produced on the Canadian Prairie while in the U.S. the Great Lakes provides an outlet to the products of the Spring Wheat Belt and the Corn Belt.

Unlike shipments of the other bulk commodities on the Great Lakes, where the largest proportion of shipments are shipments destined for the United States and Canada, grain shipments on the lakes are overwhelmingly destined for export from the United States and Canada. In recent years, Buffalo is the only Great Lakes port that has received substantial amounts of grain. The only other U. S. Great Lakes ports that are reported to have received grain in 1989 are Toledo (62,384 tons), Cleveland (70,536 tons), Port of Chicago (32,599 tons) and Duluth-Superior (354,807 tons).

The Great Lakes do not transport as much grain and soybeans as would be expected given the basin's location in the midst of or in close proximity to the major grain and soybean producing regions on the continent. This observation is reinforced when one considers that water transportation has traditionally been the

preferred (most economic) mode for shipping large volumes of bulky, low valued agricultural commodities relatively long distances. There are several reasons for this.

The most basic reason is that the Great Lakes - St. Lawrence Seaway is not the most economic route for shipping agricultural commodities from the U.S. Mid West and the Canadian Prairies to world markets. A recently published report prepared for the Saint Lawrence Seaway Development Corporation states:

> "The competitive position of the Great Lakes was analyzed with respect to a least cost routing to 33 inland origins for export grains. These inland locations represent major gathering areas for grain originating in the midwestern United States. For most of the 33 origins and trade routes evaluated, the cost economies of larger vessels at coastal ports, combined with contract unit train rates to coastal ports and barge rates to New Orleans, off-set the inland proximity of the Great Lakes ports to the 33 inland origins."

On the Canadian side of the border transportation subsidies provided by the Canadian Government work to the disadvantage of the Great Lakes. A recent report published by the Ontario Ministry of Transportation specifies the amount of subsidy per ton of grain transported by rail from a hypothetical point of origin at Brandon, Manitoba. The subsidy for transporting a ton of grain to Vancouver by rail amounts to $38.39 (Canadian) per ton. The subsidy to transport a ton of grain to Thunder Bay, where it would be loaded onto a ship and transported down the Great Lakes, amounts to $13.77 (Canadian) per ton. The difference, $24.62 Canadian, is substantial and significant. It has had a very pronounced affect in diverting grain shipments from the Great Lakes to the Canadian Pacific Coast. Whereas in 1983, 60% of Canadian grain shipments were through the Great Lakes, in 1989 less than 30% were through the lakes.

The decline in Canadian grain shipments down the lakes is troubling to the Canadian steel industry and to the Province of Ontario, where the Canadian steel industry is centered. It is also troublesome to the Province of Quebec. The reason for this is that Canadian iron ore is shipped from Quebec up through the St. Lawrence Seaway (and in the case of shipments to Nanticoke, through the Welland Canal) to the steel plants at Hamilton, Nanticoke and Sault Ste. Marie, Ontario. Because the vessels can transport iron ore as well as grain, the downbound ships transporting grain are able to return upbound with loads of iron ore. Since the upbound trip (return trip to Ontario) is a backhaul, the rate charged to ship the iron ore from the St.

Lawrence River ports to Ontario is substantially below what it would otherwise be if there were no downbound grain shipments.

The Ontario Ministry of Transportation report, referred to above, says the following:

> "Shipment of iron ore is not directly subsidized, but it has historically enjoyed the advantage of relatively low rates in vessels that would otherwise mean an empty journey into the Lakes.
>
> If low grain volumes through the Seaway continues, rates on iron ore will rise. The Seaway, suffering a revenue shortage from the loss of grain (as it inevitably will), might be forced to impose large toll increases or, in the worst possible (hypothetical) case, to curtail service. The shippers of iron ore have no attractive alternative to the Seaway. Because there is no rail connection between the mines and Ontario, the ore would have to move first by water and then be transferred to rail.
>
> While the Ontario-based steel industry sells mainly in the domestic market, it is vulnerable to foreign competition. It would be threatened by ore shipping costs that lacked either the balancing effects of the grain traffic or the advantage of using the Seaway (as indicated above)."

The above statement may overstate the potential effect that loss of grain shipments would have on the Canadian steel industry. Though it might be politically troublesome and economically expensive, the industry could shift to importing iron ore from the United States. In any case, the Province of Ontario is basically correct; the impact of the loss of the Canadian grain trade on the Great Lakes would significantly impact the Canadian steel industry. It is a situation that warrants more detailed analysis.

Limestone

Limestone is now the third most prominent commodity transported across the Great Lakes, having surpassed grain in recent years. This is not so much a reflection of growth in limestone (and gypsum) shipments as it is a reflection of the decline of grain shipments.

Limestone is a bulky, low value commodity that is very sensitive to transportation costs. It will move via the minimum

cost transportation mode. Since it is readily available in many regions of the continent and since its value is so low, long distance shipments of limestone are unusual unless an extremely low cost mode of transportation is available. Waterborne transportation is therefore the preferred mode for shipping large volumes of limestone significant distances.

Limestone is abundantly distributed along the Great Lakes. It is associated with the Niagara Questa, a geologic feature that extends from the Niagara Escarpment at Niagara Falls, New York, through the Bruce Peninsula of Ontario, along the southern shore of the Upper Peninsula of Michigan, down into the Door Peninsula of Wisconsin.

The principal uses of limestone are in the manufacture of cement and as an input into the blast furnaces of integrated steel mills. An additional significant use of limestone as stone aggregate in the manufacturing of concrete at numerous "ready-mix" plants. All three industries are well represented in the Great Lakes Basin and the regional demand for limestone is substantial. With abundant supplies, high demand and the availability of low cost water transportation, it is no surprise that large tonnages of limestone are shipped across the lakes.

The cement, concrete and steel industries are very sensitive to the business cycle. On an upswing all three tend to produce at high levels of output; on a downswing (recession) both tend to cut production substantially. With the principal consuming industries being so sensitive to the business cycle, it is not surprising to note that shipments of limestone have fluctuated widely in the 1979-88 period. Minimum tonnages (12.6 million) were shipped during the recession of 1982 while maximum tonnages (24.1 million) were shipped in 1988 (Table 21). Most probably it is the swing in the output of the cement and concrete industries, more than the swing in output of the steel industry, that accounts for most of the variation in shipments.

Shipments of limestone across the Great Lakes originate at United States harbors; there are no known commercial shipments of limestone on the lakes that originate in Canadian harbors. Eight harbors are consistent ports of origin of limestone shipments on the lakes (Table 21). Of the eight, three (Calcite, Stoneport and Port Dolomite) are dominant (Table 22). These three characteristically originate 75% to 80% of all limestone shipments across the lakes. All eight of the limestone harbors are private; none receives any expenditures of Federal funds.

TABLE 21. GREAT LAKES LIMESTONE AND GYPSUM SHIPMENTS, 1979 - 1988
(Tons)

	LIMESTONE								GYPSUM			
	Lake Michigan	Lake Huron					Lake Erie		Lake Huron			
Year	Port Inland	Drummond Island	Port Dolomite	Calcite	Stoneport	Sub Total	Marblehead	Total Limestone	Port Gypsum	Alabaster	Total Gypsum	System Total
1988	3,384,389	517,696	4,130,564	10,021,537	8,223,101	26,277,287	925,658	27,202,945	374,733	612,476	987,209	28,190,154
1987	3,143,667	1,478,229	2,856,328	8,130,025	7,906,070	23,514,319	1,098,332	24,612,651	430,751	629,375	1,060,126	25,672,777
1986	2,638,166	1,300,619	1,722,313	6,843,000	6,544,466	19,048,563	841,029	19,889,592	439,932	618,963	1,058,895	20,948,487
1985	2,273,516	1,187,264	2,043,666	7,696,512	6,438,032	19,638,969	581,925	20,220,894	365,562	576,233	941,866	21,162,749
1984	2,219,334	1,090,809	2,257,934	7,712,006	5,886,856	19,166,938	784,465	19,950,403	322,298	555,692	877,990	20,828,393
1983	1,904,223	1,129,230	1,476,376	6,039,280	5,347,206	15,896,314	526,508	16,422,822		499,936	499,936	16,922,758
1982	2,010,772	811,579	1,428,527	5,258,873	3,928,834	13,438,585	551,038	13,989,823			0	13,989,623
1981	2,770,862	1,476,801	2,804,611	7,920,465	6,142,240	21,114,979	890,952	22,005,931		300,086	300,086	22,306,017
1980	3,005,691	1,489,228	2,978,917	7,427,977	7,341,278	22,243,091	1,030,290	23,273,381	335,907	389,864	725,771	23,999,152
1979	3,869,607	2,044,798	3,834,696	10,277,707	9,344,514	29,371,324	1,199,851	30,571,176	601,198	698,149	1,299,347	31,870,522

Source: 1979 Through 1988, Waterborne Commerce of the United States, Part 3, Waterways and Harbors Great Lakes

TABLE 22. PERCENTAGE DISTRIBUTION OF GREAT LAKES LIMESTONE AND GYPSUM SHIPMENTS, 1979 - 1988

	LIMESTONE								GYPSUM			
	Lake Michigan	Lake Huron					Lake Erie		Lake Huron			
Year	Port Inland	Drummond Island	Port Dolomite	Calcite	Stoneport	Sub Total	Marblehead	Total Limestone	Port Gypsum	Alabaster	Total Gypsum	System Total
1988	12.0	1.8	14.7	35.5	29.2	93.2	3.3	96.5	1.3	2.2	3.5	100.0
1987	12.2	5.8	11.1	31.7	30.8	91.6	4.3	95.9	1.7	2.5	4.1	100.0
1986	12.6	6.2	8.2	32.7	31.2	90.9	4.0	94.9	2.1	3.0	5.1	100.0
1985	10.7	5.6	9.7	36.4	30.4	92.8	2.7	95.5	1.7	2.7	4.5	100.0
1984	10.7	5.2	10.8	37.0	28.3	92.0	3.8	95.8	1.5	2.7	4.2	100.0
1983	11.3	6.7	8.7	35.7	31.6	93.9	3.1	97.0	0.0	3.0	3.0	100.0
1982	14.4	5.8	10.2	37.6	28.1	96.1	3.9	100.0	0.0	0.0	0.0	100.0
1981	12.4	6.6	12.6	35.5	27.5	94.7	4.0	98.7	0.0	1.3	1.3	100.0
1980	12.5	6.2	12.4	31.0	30.6	92.7	4.3	97.0	1.4	1.6	3.0	100.0
1979	12.1	6.4	12.0	32.2	29.3	92.2	3.8	95.9	1.9	2.2	4.1	100.0

Source: 1979 Through 1988, Waterborne Commerce of the United States, Part 3, Waterways and Harbors Great Lakes

With very few exceptions, all major harbors that are Federally maintained receive receipts of limestone. The few that do not are marginally above the 250,000 ton base which delineates a "major" from a "minor" harbor. Even most of the minor harbors receive shipments of limestone. Limestone tends to move from the eastern tip of the Upper Peninsula and the northern tip of the Lower Peninsula of Michigan in both directions, up as well as down the lakes.

A recent trend in limestone shipments that is not reflected in the 1988 statistics is the shipment of limestone to taconite plants at the Head of the Lakes. At the taconite plants, the limestone is mixed with the iron ore in production of the taconite (iron ore) pellets. Pellets that contain limestone are referred to as "flux pellets". This has caught on in the past two to three years and increasing amounts of limestone are being transported for this purpose to the pellet plants.

Other Bulk Commodities

There are three remaining commodity groups that are shipped in significant volumes across the Great Lakes -- potash, cement and petroleum products. In aggregate their tonnages are significant. The quantity ranged from 25.5 million tons in 1979 to a low of 17.0 million tons in 1987 (Table 23 and Figure 23). Their share of all seven bulk commodities has not varied as much as the tonnage figures might appear to indicate. The maximum share (13.5%) was attained in the 1982 recession and the minimum share (9.8%) was attained in 1988 (Table 24). To a limited degree their share is "counter cyclical", being highest in a recession and minimum in an expansion period.

<u>Potash</u> shipments make up the smallest tonnage of the three commodities in this group. Its volume varied from a low of 477,699 tons in 1979 to a high of 2.0 million tons in 1984. The low figure should be ignored as 1979 was only the third or fourth year potash had been shipped across the lakes. Excluding 1979 and 1980, the volume has remained reasonably stable at 1.5 to 2.0 million tons per year.

Potash is a fertilizer mineral mined in southeastern Saskatchewan. The mineral is transported by rail to Thunder Bay, Ont. where it is loaded into self-unloading vessels and transported down the lakes to U.S. and Canadian (Ontario) ports.

Potash also is produced in the Maritime Province of New Brunswick, Canada. In recent years New Brunswick potash has been granted an advantage over Saskatchewan potash. The advantage is a rail subsidy granted to commodities shipped west from the Maritime Provinces into Central Canada. With the advent of that subsidy New Brunswick potash has been successfully competing with Saskatchewan potash in the Ontario market. Thus, unless the

TABLE 23. "OTHER" BULK COMMODITIES TRANSPORTED ON THE GREAT LAKES, 1979 - 1990

(Tons)

Year	Cement	Potash	Petroleum U.S.	Petroleum Canada	Petroleum Sub-total	Total
1990	4,501,904	1,497,167	3,344,149	9,551,516	12,895,665	18,894,736
1989	4,479,295	1,586,531	3,010,202	8,094,386	11,104,592	17,170,418
1988	4,162,954	1,576,347	2,801,229	9,216,414	12,017,643	17,756,944
1987	3,805,788	1,702,174	2,821,489	8,669,669	11,491,158	16,999,131
1986	4,082,975	1,629,493	2,735,337	9,251,687	11,987,024	17,699,492
1985	3,398,789	1,857,561	3,021,573	9,862,367	12,883,940	18,140,290
1984	3,408,621	2,032,470	3,217,865	11,744,011	14,961,876	20,402,967
1983	3,284,106	1,599,778	3,085,751	11,878,493	14,964,244	19,848,128
1982	3,021,696	1,813,142	2,888,365	11,462,922	14,351,287	19,186,125
1981	3,706,778	1,593,556	3,950,112	11,717,555	15,667,667	20,968,001
1980	4,213,053	891,171	5,397,682	13,631,175	19,028,857	24,133,081
1979	5,393,839	477,699	5,782,665	13,798,717	19,581,382	25,452,920

Source: 1979 Through 1990, Annual Reports, Lake Carriers Association.

TABLE 24. PERCENT SHARE BY COMMODITY OF "OTHER" BULK COMMODITIES TRANSPORTED ON THE GREAT LAKES, 1979 - 1990

Year	Cement	Potash	Petroleum U.S	Petroleum Canada	Petroleum Sub-total	Total
1990	23.83	7.92	17.70	50.55	68.25	100.00
1989	26.09	9.24	17.53	47.14	64.67	100.00
1988	23.44	8.88	15.78	51.90	67.68	100.00
1987	22.39	10.01	16.60	51.00	67.60	100.00
1986	23.07	9.21	15.45	52.27	67.73	100.00
1985	18.74	10.24	16.66	54.37	71.02	100.00
1984	16.71	9.96	15.77	57.56	73.33	100.00
1983	16.55	8.06	15.55	59.85	75.39	100.00
1982	15.75	9.45	15.05	59.75	74.80	100.00
1981	17.68	7.60	18.84	55.88	74.72	100.00
1980	17.46	3.69	22.37	56.48	78.85	100.00
1979	21.19	1.88	22.72	54.21	76.93	100.00

Source: 1979 Through 1990, Annual Reports, Lake Carriers Association (draft).

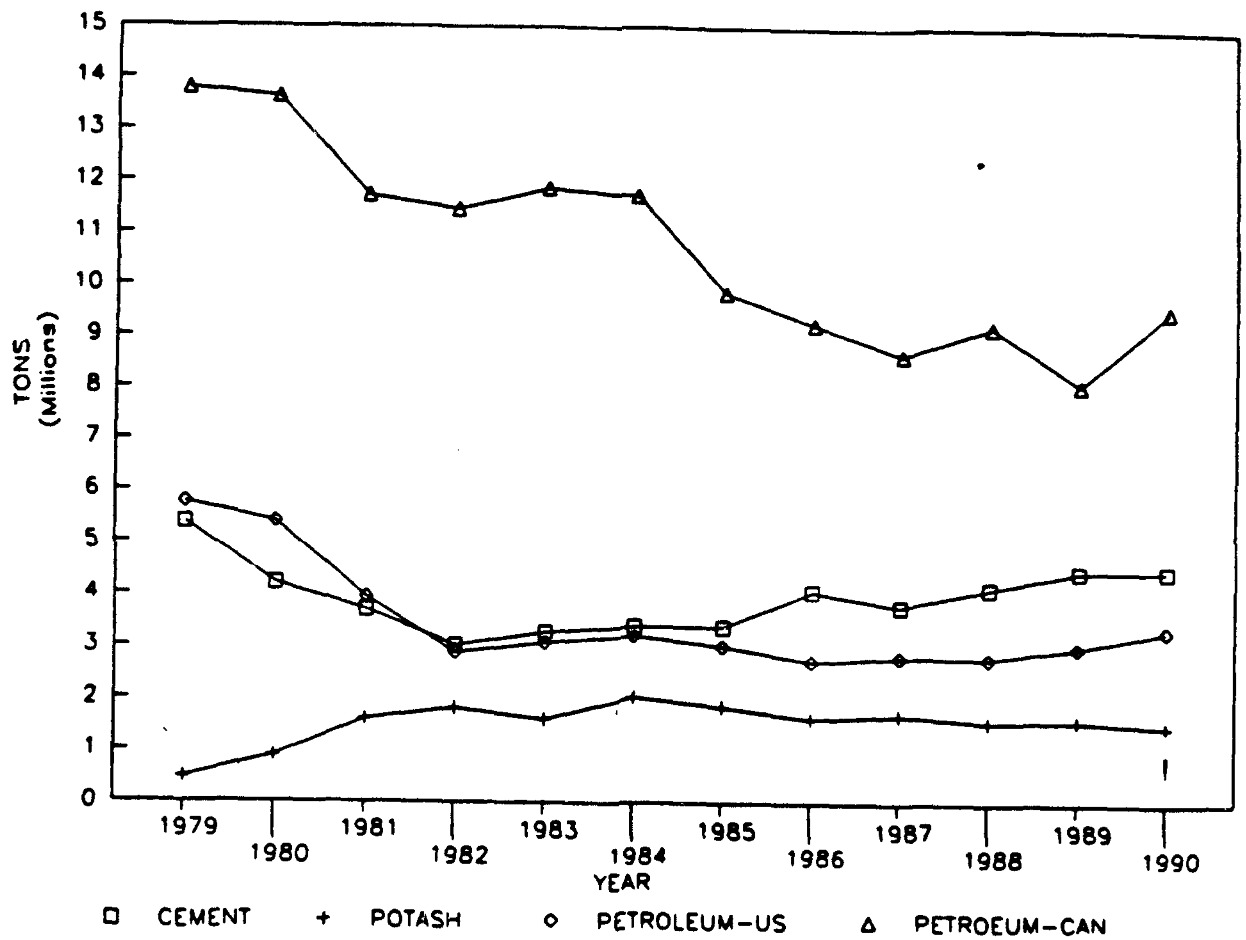


FIGURE 23. "OTHER BULK" COMMODITIES TRANSPORTED ON THE GREAT LAKES, 1979-1990

subsidy is removed, it is unlikely there will be any growth in shipments of Saskatchewan potash across the lakes to Canadian markets. Any potential for growth appears to be restricted to expansion of the market in the U.S. Corn Belt.

Cement is the second most prominent of the three other bulk commodities. The cement trade upon the Great Lakes is both simple and complex. It is simple in that there are only two water-side cement producers on the U.S. side of the Great Lakes. They are located in Charlevoix and Alpena, Michigan.

The manufacture of cement is an industry in which economies of scale are important. The producer at Alpena, a water-side location in close proximity to the industry's principal (non-energy) raw material (limestone), can produce cement at a relatively low cost and distribute its product up and down the lakes at a competitive price. This is not to imply that this lakeside producer has a monopoly on the market in the Great Lakes Basin. The cement industry is highly competitive and Canadian producers aggressively pursue the U.S. market. Substantial amounts of cement are imported into the Great Lakes states from Canada.

The complex part of the industry lies in the use of cement and in the physical characteristics of the resulting product. Cement is the principal ingredient in concrete. Cement, crushed aggregate (usually limestone) and water are combined to produce concrete. The resulting product is very bulky, relatively inexpensive and difficult to handle. Concrete is generally produced at one or more "ready mix" plants in each major, and also in many minor, metropolitan areas. Thus, the demand for cement is tied to the construction industry and in turn to major metropolitan areas. Being a bulky product with a modest value per ton, cement is well suited to waterborne shipment.

At the national and international level the production and transportation of cement has been changing rapidly. There has been a substantial increase of imports of cement into the United States, a number of mergers (or joint ventures) of U.S. and foreign firms, and a trend toward more efficient production and distribution of the finished product. One aspect of that change is affecting waterborne transportation on the Great Lakes.

There appears to be a trend to increased shipments of cement by water, and in the water mode, to more shipment by self-unloading bulk freighters. In the summer of 1991, the Alpena, Mich. producer purchased an older iron ore freighter and reduced its size. This is the first time a commercial Great Lakes ship has been reduced in size. A number of older ships have been increased ("stretched") in size, but until now none has been reduced in size. The vessel is to be used to transport cement to the smaller river harbors, where because of narrow channels and less draft, larger ships cannot be efficiently used.

What tends to make this even more interesting is the interaction of this apparent need for small, self-unloading freighters to transport cement and a similar need for such vessels to transport coal. The recently passed Clean Air Act has substantially increased electric utility interest in blending, at least on a test basis, low sulfur Western coal with higher sulfur, but higher energy producing Eastern coal. As many of the older electric utility plants are located along channels with less than Seaway draft, there currently is a shortage of shallow self-unloading freighters needed to serve these plants. It is premature to draw any conclusion, but it is not improbable that a number of older, relatively small (by iron ore vessel standards) self-unloaders may be downsized to serve the emerging Western coal and cement trades on the Great Lakes.

<u>Petroleum Products</u> account for most, usually more than two-thirds, of "Other" Bulk Commodities transported across the Great Lakes. As the term implies, this category refers to products produced from crude petroleum. Included are such products as fuel oils, gasoline, asphalt, kerosene, naphtha and others. The category does not include crude petroleum; no crude petroleum is shipped by water across the Great Lakes.

The volume of petroleum products shipped across the lakes declined from 19.6 million tons in 1979 to 12.9 million tons in 1990 (Table 23). Most of the petroleum products originate at Canadian ports. Characteristically, less than 25% originates at U.S. ports on the Great Lakes. Most of Canadian shipments originate at the Port of Sarnia, Ontario. Though most Canadian petroleum products are destined for Canadian markets, a significant amount enters the United States.

There are reasons to question the data on petroleum products shipped across the Great Lakes. The trade and transportation of petroleum products is very complex. Additionally, on the Great Lakes there appears from time to time a pattern of shipments of petroleum products transported from one country to the other that appears to be, but is not, irrational. Such movements generally relate to differences in tax legislation and value of the dollar in the two countries. Also, the Corps' Gray Book statistics indicate that the principal petroleum product shipping ports on the lakes also receive significant amounts of product, indicating the possibility of a significant amount of cross-hauling and double counting.

All of the above notwithstanding, the spatial flow of petroleum products across the lakes is reasonably clear. Petroleum products shipped across the lakes must necessarily originate at petroleum refineries located on the lakes or the connecting channels between individual lakes. The most prominent petroleum refining centers on the lakes are the Chicago metropolitan area on Lake Michigan and Sarnia, Ont. on the St. Clair River.

On the U.S. side petroleum products - principally fuel oils, gasoline and asphalt - are shipped from the Port of Chicago and Indiana Harbor to secondary metropolitan areas along the lakes - Detroit, Toledo, Cleveland and Buffalo for distribution within the hinterland of each. Additionally, petroleum products are distributed from the Chicago area to smaller cities located along Lake Michigan; these are largely shipments of fuel oil.

VIABILITY OF THE STEEL INDUSTRY

For the better part of a century the viability of the integrated iron and steel mills located along the shores of the Great Lakes and at nearby inland locations has been unquestioned. In the past two decades that situation has changed. A number of mills have permanently closed and others have been sold or dismantled. While a number of factors have contributed to this process, the primary factors have been the age of the affected plants, the increase in international competition in the industry and the consequential dramatic increase in steel imports, and the appearance of steel "mini-mills" in the United States.

Mini-mills are relatively small steel producers, usually producing less than one million tons of steel per year, using electric-furnaces charged with scrap to produce a limited range of steel products. The integrated mills are usually substantially larger, producing more than one million tons per year, using a combination of open-hearth and basic oxygen furnaces (b.o.f.) that are primarily charged with pelletized iron ore. Historically integrated mills have produced a wide range of steel products.

Mini-mills have been in existence for more than 30 years and they have been successful in capturing an increasing proportion of the domestic steel market. Traditionally, they have concentrated on "fringe" products of the iron and steel industry -- initially reinforcing bar (rebar). Gradually, however, they have expanded into other steel products including wire and, in recent years, structural steel.

The expansion of mini-mills has been at the expense of the integrated mills. As the former have progressed from producing one product to another, the characteristic reaction of the integrated mills has been to abandon the threatened portion of their market. For a variety of reasons the integrated mills have not been competitive with the mini-mills over a limited range of steel products.

Recently mini-mills have introduced another factor into the domestic steel industry -- thin-slab casting. This technology,which has been successfully implemented for the first time by Nucor Corporation at its Crawfordsville, Ind. plant, has enabled Nucor to produce a basic product of the steel industry -- plate steel at an extremely competitive price. It has been

estimated that with its thin-slab technology Nucor's costs are about $75 per ton below those of competing integrated mills. A current handicap of the thin-slab casting process is that, while the quality of the plate has improved, it is still not at the quality required by the automotive industry -- the major consumer of plate steel.

Plate steel is a major product of the North American steel industry. Perhaps more importantly, it is the more profitable portion of the industry. As the integrated mills have come under increasing competition with consequential diminished profits, they have tended to concentrate to an increasing extent on the production of the relatively highly profitable, high quality plate steel principally destined for the automotive industry. The plate market is a market the integrated mills cannot afford to lose. If they cannot compete they will lose this market, and in the process, they will lose a major portion of their North American market.

There is more to the competition of mini-mills with the new thin-slab casting technology than a price differential. There are considerations of the quality of the product and of the future availability of quality scrap steel needed to charge the electric furnaces of the mini-mills, and of course the price (cost to the mill) of the necessary quality scrap. Additionally, there is nothing in the technology of thin-slab casting that prevents it from being implemented by the integrated mills. Nevertheless, the mini-mills and the new technology represent a new, serious threat to the integrated mills. Very importantly, the threat comes at a time when a number of the integrated mills are having very serious financial problems.

In the summer of 1991 there were 13 integrated steel mills located along the Great Lakes; nine in the U.S. and four in Canada. Additionally, there are seven more integrated mills at inland sites that use pelletized iron ore transported across the Great Lakes and shipped by rail to their location (Table 25). All 20 mills produce steel with the traditional blast furnace technology using pelletized iron ore as the iron charge for the furnace (Table 25). The question that must be answered is: how many will survive by the year 2000? by 2010? by 2020?

There is a consensus in the industry that in the foreseeable future, through the year 2000 at a minimum (and probably longer), there will not be any construction of new integrated mills or any new blast furnaces, on the Great Lakes. The most recently constructed ("greenfield") mills on any of the Great Lakes were Bethlehem Steel Corporation's Burns Harbor facility in Indiana and Stelco's (Steel Company of Canada, Ltd.) Nanticoke mill on Lake Erie. The former was constructed in the 1960s while the latter was constructed in the 1970s.

TABLE 25. IRON AND STEEL MILLS WITH BLAST FURNACE OPERATIONS ON THE GREAT LAKES AND AT INLAND LOCATIONS, 1991

Mills Located on a Great Lake

	Corporation	Location
1	Bethlehem Steel Corp.	Burns Harbor, Ind.
2	Inland Steel Co.	Indiana Harbor, Ind.
3	US Steel	Gary, Ind.
4	McLouth Steel Products, Corp.	Trenton, Mich.
5	Great Lakes Steel	Ecorse, Mich.
6	Rouge Steel	Dearborn, Mich.
7	LTV Corp.	Cleveland, Ohio
8	LTV Corp.	Indiana Harbor, Ind.
9	US Steel	Lorain, Ohio
10	Algoma Steel	Sault St. Marie, Ont.
11	Dofasco	Hamilton, Ont.
12	Stelco	Hamilton, Ont.
13	Stelco	Nanticoke, Ont.

Mills at an Inland Site

	Corporation Name	Location
1.	Sharon Steel Co.	Sharon, Pa.
2.	Armco, Inc.	Ashland, Ky.
3.	Armco, Inc.	Middletown, Oh.
4.	Weirton Steel Corp.	Weirton, W. Va.
5.	Wheeling-Pittsburg Steel	Steubenville, Ohio
6.	Warren Consolidated Industries	Warren, Ohio
7.	Acme Steel Corp.	Interlake, Ill.

In the past decade there has been substantial capital investment in many of the integrated mills on the Great Lakes, investment in modernization that was necessary to remain competitive. Business conditions permitting, capital investment for modernization will continue in some, but not all, of the existing integrated mills. Those not modernized will close.

Neither the number nor identity of mills that will close by the year 2000 can be accurately predicted. Numerous factors affect such decisions and most of the knowledge needed to arrive at a closure decision is not available to the public. Nevertheless, it appears very probable that one or more of the 20 integrated mills operating in the Great Lakes Basin in 1991 will not operate in the year 2000. The number of mills that might close (in all or part) could be as many as five. The probability that one mill will close is extremely high; it is almost a

certainty. The probability that all five will close is much less; it is very unlikely.

The effect of the mill closures would be to reduce the amount of iron ore transported across the Great Lakes. Since it is not possible to reliably predict the steel capacity that would be lost, it is not possible to predict the amount of iron ore that would not be transported across the lakes. It is known that approximately 1.2 tons of pelletized iron ore are shipped per ton of steel produced. If one mill were to close with a loss of one million tons of steel, there would be 1.2 million tons less of pelletized iron ore shipped. With the advent of the flux (calcified) pellets (addition of limestone into the pellets at the pellet plant), an additional 75 pounds of limestone shipments would be lost per ton of iron ore pellets shipped.

In summary, precluding an unforeseen boom in the domestic steel industry (highly improbable), the industrial geography of the integrated iron and steel mills situated on the Great Lakes will change marginally between 1991 and the year 2000. The major mills will remain and the great bulk of the iron ore and limestone transported to the mills by waterborne carriers will remain. However, there will be fewer mills located in the region in the year 2000 and they will produce lesser amounts of steel with a corresponding reduction in the amount of iron ore and, to a much lesser degree, of limestone transported across the lakes. The magnitude of the decline cannot be accurately predicted but the trend is clear; it is one of continued secular decline.

An additional topic that could affect the spatial location of steel mills is the possible implementation of either direct reduction or "iron carbide" technology. Direct reduction would permit the use of iron ore in electric furnaces, replacing the need to use scrap as the basic raw material. The iron carbide technology, which is most recent, would allow the use of iron ore and scrap in electric furnaces. To the extent that the growth of mini-mills and electric furnaces appears to be limited by the availability of quality scrap at competitive prices, both technologies would, if commercially implemented on a large scale, tend to favor the mini-mills and their electric furnaces. Thus the locational pattern of the industry might shift -- away from the lake-side integrated mills toward inland "mini-mills".

It is not evident that the above mentioned processes will be commercially implemented on a large scale nor that the locational pattern of the industry would shift. Even if the locational pattern of the industry did shift, the effect on the volume of ore transported across the Great Lakes is not immediately evident. Nevertheless, the technology should be watched as it could significantly affect the location of steel plants and the demand for waterborne transportation across the lakes.

TRAFFIC FORECASTS

There is considerable interest in forecasts of commercial navigation activity on the Great Lakes. This section discusses two set of traffic forecasts. The first set are forecasts of traffic through the Soo Locks prepared by the Army Corps of Engineers. The second are projections provided by the St. Lawrence Seaway Development Corporation. In both cases, the concern in this report is with the short-term future - to the year 2000. Any forecasts beyond 2000 have not been addressed.

Traffic Through the Soo Locks

The Final Interim Feasibility Report for the Great Lakes Connecting Channels and Harbor Study, published in March 1985, provided forecasts of all traffic (U.S., Canadian and other foreign) through the Soo Locks for the period 1990 to 2050 (Table 26). Hereafter, forecasts from this report are referred to as the "1985 forecast."

The Sault Ste. Marie Lock Traffic Study, published in May 1991, revised the above forecasts and adjusted them to reflect the historical record of traffic through the Soo Locks in the 1985-90 interval (Table 27). Hereafter, forecasts from this report are referred to as the "1991 forecast."

Differences between the two forecasts, 1991 minus 1985, are presented in Table 28. In this table **a negative value reflects a decrease** in the 1991 forecast compared to the 1985 forecast; **a positive value reflects an increase** in the 1991 forecast compared to the 1985 forecast.

The principal difference in the two forecasts lie in four commodities: grain, iron ore, coal and limestone. The most prominent change was a substantial reduction in the volume of grain projected to move through the Soo Locks. Whereas the 1985 projection was a total of 35.1 million tons in 2000, the 1991 projection was 14.6 million tons in 2000. The change, a decline of 20.5 million tons, represents a 58% reduction from the 1985 forecast. Virtually all of the decline is projected to accrue to downbound shipments of grain.

The volume of iron ore projected to move through the Soo Locks also was reduced substantially. The 1985 forecast was for a total of 60.3 million tons in 2000. The revised 1991 forecast for the same year is 47.2 million tons. This represents a decline of 12.8 million tons (21.4%) from the 1985 forecast. Virtually all of the decline is projected to accrue to downbound shipments of iron ore.

TABLE 26. 1985 FORECAST OF TRAFFIC THROUGH THE SOO LOCKS, 1990 - 2050

(1,000 tons)

Downbound	1990	2000	2010	2050
Iron Ore	55,000	60,000	65,000	65,000
Coal	11,700	17,300	18,000	18,000
Grain	34,900	35,100	35,100	35,100
Stone	0	0	0	0
Other Bulk	2,400	2,700	3,200	3,200
General Cargo	1,000	1,100	1,200	1,200
Subtotal	105,000	116,200	122,500	122,500
Upbound				
Iron Ore	200	300	300	300
Coal	5,400	6,900	7,500	7,500
Grain	0	0	0	0
Stone	2,300	2,500	2,900	2,900
Other Bulk	3,000	3,500	4,100	4,100
General Cargo	900	900	1,100	1,100
Subtotal	11,800	14,100	15,900	15,900
Both Directions				
Iron Ore	55,200	60,300	65,300	65,300
Coal	17,100	24,200	25,500	25,500
Grain	34,900	35,100	35,100	35,100
Stone	2,300	2,500	2,900	2,900
Other Bulk	5,400	6,200	7,300	7,300
General Cargo	1,900	2,000	2,300	2,300
TOTAL	116,800	130,300	138,400	138,400

Source: Table 1, Sault St. Marie Lock Traffic Study, Detroit: U.S. Army Corps of Engineers, Detroit District, March 1985, p.4.

TABLE 27. 1991 FORECAST OF TRAFFIC THROUGH THE SOO LOCKS, 1990 - 2050 1/

(1,000 tons)

Downbound	1990	2000	2010	2050
Iron Ore	49,600	47,169	47,169	47,169
Coal	13,500	17,300	18,000	18,000
Grain	13,800	14,500	16,000	16,000
Stone	374	400	400	400
Other Bulk	1,500	1,800	2,000	2,000
General Cargo	1,500	1,200	1,200	1,200
Subtotal	80,274	82,369	84,769	84,769
Upbound				
Iron Ore	10	12	12	12
Coal	2,400	2,500	2,500	2,500
Grain	114	80	75	75
Stone	3,600	5,100	5,100	5,100
Other Bulk	1,100	1,200	1,200	1,200
General Cargo	464	400	400	400
Subtotal	7,688	9,292	9,287	9,287
Both Directions				
Iron Ore	49,610	47,181	47,181	47,181
Coal	15,900	19,800	20,500	20,500
Grain	13,914	14,580	16,075	16,075
Stone	3,974	5,500	5,500	5,500
Other Bulk	2,600	3,000	3,200	2,200
General Cargo	1,964	1,600	1,600	1,600
TOTAL	87,962	91,661	94,056	94,056

Source: Table 16, Sault Ste. Marie Lock Traffic Study, Detroit: U.S. Army Corps of Engineers, Detroit District, May 1991, p. 39.

1/ The 1990 value is the actual volume of traffic recorded to have passed through the Soo Locks in 1990. Values for subsequent years are forecasted values.

TABLE 28. DIFFERENCE: 1985 FORECASTED VOLUMES MINUS 1991 FORECASTED VOLUMES FOR THE SOO LOCKS, 1990 - 2050 1/
(1,000 tons)

Downbound	1990	2000	2010	2050
Iron Ore	-5,400	-12,831	-17,831	-17,831
Coal	1,800	0	0	0
Grain	-21,100	-20,600	-19,100	-19,100
Stone	374	400	400	400
Other bulk	-900	-900	-1,200	-2,200
General Cargo	500	100	0	0
Subtotal	-24,726	-33,831	-37,731	-38,731
Upbound				
Iron Ore	-190	-288	-288	-288
Coal	-3,000	-4,400	-5,000	-5,000
Grain	114	80	75	75
Stone	1,300	2,600	2,200	2,200
Other Bulk	-1,900	-2,300	-2,900	-2,900
General Cargo	-436	-500	-700	-700
Subtotal	-4,112	-4,808	-6,613	-6,613
Both Directions				
Iron Ore	-5,590	-13,119	-18,119	-18,119
Coal	-1,200	-4,400	-5,000	-5,000
Grain	-20,986	-20,520	-19,025	-10,025
Stone	1,674	3,000	2,600	2,600
Other Bulk	-2,800	-3,200	-4,100	-4,100
General Cargo	64	-400	-700	-700
TOTAL	-28,838	-38,639	-44,344	-45,344

1/ For 1990, the values represent difference from the 1985 projected value for that year and the volume actually recorded in 1990. For 2000 and all subsequent years, the values represent differences between the 1985 and 1991 projected values. A negative value represents a reduction from the 1985 forecast. A positive value represents an increase from the 1985 forecast.

Unlike iron ore and grain, the volume of stone forecasted to move through the Soo Locks has increased from the 1985 to the 1991 forecast. The earlier forecast projected that a total of 2.5 million tons would move through the Soo Locks in 2000; the later forecast increased that volume to 5.5 million tons at the same year, an increase of 3.0 million tons or 120%. The principal reason for the increase has been the recent appearance (since 1985) of shipments of fluxstone, a mixture of limestone and dolomite, which is added to iron ore in the pelletizing process. Thus the increase primarily accrues to upbound shipments of stone.

The volume of coal projected to move through the Soo locks in the 1991 forecast is less than that specified in the 1985 forecast. The 1991 volume, 19.8 million tons, is significantly below the 1985 forecast of 24.2 million tons. The difference, a reduction of 4.4 million tons represents a reduction of 18.2% from the 1985 forecast. The reason for the decrease in total coal movements lies in the reduction of upbound shipments of coal; this is Eastern Coal moving to thermal electric plants along the shores of Lake Superior in Canada and the U.S. Whereas the 1985 report forecasted upbound movements of 6.9 million tons of coal, the 1991 report reduced that figure to 2.5 million tons. Interestingly, downbound shipments of coal (Western Coal) are the same in both forecasts - 17.3 million tons.

The 1991 forecasts are much more realistic than the 1985 forecasts primarily because they reflect historical movements in the intervening 1985-90 period. The changes introduced in the 1991 forecasts as compared to the 1985 forecasts move in the correct direction and are consistent with the analysis of commodity flows provided above. It is our conclusion that the 1991 forecasts are an acceptable basis for planning purposes. There are, however, some questions that might be asked of individual forecasts for the year 2000.

The 1991 forecast of 14.6 million tons of grain moving through the Soo Locks in 2000 is accepted with the qualification that it includes a projected increase of grains shipped from the Great Lakes to the Soviet Union as that country makes the transition to a free market economy. If the 1991 forecast excludes increased grain shipments to the Soviet Union, then the forecast is judged to be too high. A preferred value would be about 14.0 million tons in 2000.

The 1991 forecast of 47.2 million tons of iron ore for the year 2000 is reasonable and well within the acceptable range of error given the intrinsic difficulty of making forecasts. If one were to hedge that value, one might argue for 45 or 46 million tons.

The 1991 forecasts of coal shipments for the year 2000 pose a problem that is difficult to resolve at this time. The downbound projection of 17.3 million tons is certainly acceptable; it might even be low. However, given the need for lead time to develop additional coal loading facilities at Duluth-Superior, the published figure is accepted. The only qualification that would be provided is the concern about increased competitiveness of rail as a means of transporting Western Coal. It is conceivable that railroads could capture a significant proportion of the proposed increase in waterborne transportation of Western Coal across the lakes.

The major problem with the 1991 coal forecast for the year 2000 lies with the projection of 2.5 million tons of coal transported upbound through the Soo Locks. As stated, this is Eastern Coal being transported to thermal electric plants situated along the Canadian and U.S. shores of Lake Superior. When one considers the potential effect of clean air legislation, and the proximity of these plants to Western Coal available at Duluth-Superior, one must question whether the decline in shipments of Eastern Coal upbound through the Soo has bottomed out. It is accepted that the upbound shipment of Eastern Coal will not terminate but our estimate would be 2.0 million tons in 2000. Once again, it should be noted that the difference, 0.5 million tons, is not great and within the acceptable range of error.

The 1991 forecast of shipments of 5.1 million tons of stone upbound is based upon an implicit continued growth in the demand for fluxstone at the iron ore pelletizing plants at the Head of the Lakes. While it is agreed that this commodity flow will probably be greater in 2000 than in 1990, there is no known consensus as to the volume that will be reached in 2000. With a projected decline in steel capacity, and a corresponding decline in iron ore shipments, one could argue for a halt in the growth of upbound fluxstone shipments. However, as the use of fluxstone is still expanding, and it is not known to what extent the pelletizing plants have accepted its use, it is not improbable to forecast an increase in shipments of this commodity while simultaneously forecasting a lower level of iron ore shipments. Once again it is concluded that the 1991 forecast lies within an accepted range of error.

Traffic Through the St. Lawrence Seaway

The St. Lawrence Seaway Development Corporation, the entity that operates the U.S. portion of the Seaway, has provided projections of traffic through the Seaway (Table 29). The data refer to total traffic through the Seaway irrespective of the country of origin or destination. Unlike the data in this report, which are presented in net tons of 2,000 pounds, the Seaway data are presented in metric tons of 2,204 pounds.

Since this report did not attempt to analyze traffic through the Seaway, the data is presented without comment except to note that grain projections exclude any future exports to the Soviet Union that might result from their need for additional food as they attempt to make the transition to a free market economy. Shipments of significant amounts of grain, either from Canada or the U.S., might significantly raise the figures for grain in Table 29.

TABLE 29. TRAFFIC THROUGH THE ST. LAWRENCE SEAWAY, 1990-1998
(million metric tons)

Commodity	Actual 1990	Projected 1992	1994	1996	1998
Grain	12.23	12.50	12.82	13.16	13.50
Gov't Aid	.08	.00	.00	.00	.00
Iron Ore	11.53	11.83	12.14	12.46	12.79
Coal	.49	.50	.52	.53	.54
Other Bulk	8.58	8.80	9.03	9.27	9.51
General Cargo	3.75	3.85	3.95	4.00	4.10
Total	36.66	37.48	38.46	39.42	40.44

Source: St. Lawrence Seaway Development Corporation, Washington, D.C., Sept. 1991.

CHAPTER 6

HARBORS

The previous chapter has shown significant tonnages of several commodities are shipped on the Great Lakes. Although all shipments originate at a harbor and terminate at a harbor, one of the two harbors need not be on the Great Lakes. However, as the vast majority of all shipments on the lakes are intra-basin shipments, most shipments originate and terminate in a Great Lakes harbor. The harbor may be in the United States or Canada but it is likely to be on the Great Lakes.

This chapter provides a brief overview of United States harbors on the Great Lakes. Topics discussed include recent historical trends in traffic, the association of harbors and commodities transported, a summary of harbors classified by depth, a rank order of individual harbors, and a listing of private commercial harbors. It must be noted that the data relate to total tons shipped and received from individual harbors. Because of transhipments a receiving harbor also may be an originating harbor. As a result, a relatively small amount of "double counting" enters into the data. Nevertheless as an individual harbor usually receives and ships commodities, total tons shipped and received are the appropriate statistic.

DATA AND DEFINITIONS

Four sets of statistical data are presented for the U.S. harbors on the Great Lakes. Table 30 presents historical data on tons of commodities transported at all harbors, private and Federal, for the 1984-1989 period. Table 31 presents a summary of all harbors classified by harbor depth. Table 32 presents a rank ordered listing of all harbors based upon tonnages transported at individual harbors in 1989. Table 33 presents a listing of private harbors and the tonnages transported through each harbor in 1989.

To simplify the presentation of data, harbors have been subdivided into "major" and "minor" harbors. This is not a classification used by the U.S. Army Corps of Engineers; it is merely a classification developed in this report. A major harbor is defined to be one through which 250,000 or more tons have moved in 1988. A minor harbor is one through which less than 250,000 tons have moved in 1988.

The harbors listed in the tables are those that shipped or received waterborne commerce in the years 1984-1989. Based on this use for commercial purposes, they are referred to herein as

TABLE 30. SHIPMENTS AND RECEIPTS AT U.S. GREAT LAKES HARBORS, 1984 - 1989

(Tons)

	1984	1985	1986	1987	1988	1989
Lake Superior						
Major Harbors						
Ashland Harbor, Wis.	96,558	166,524	133,724	63,738	331,935	120,653
Marquette Harbor, Mich.	180,473	178,318	356,823	616,652	729,310	770,414
Presque Isle Harbor, Mich.	6,848,430	7,202,744	4,701,530	9,332,587	11,433,323	12,155,757
Silver Bay, Minn. *	4,146,166	3,962,646	1,636,518	0	0	60,068
Duluth-Superior Harbor, Minn. & Wis.	37,255,941	28,816,841	29,155,300	36,462,867	40,002,268	40,802,541
Taconite Harbor, Minn. *	4,175,292	5,446,124	6,101,942	7,555,009	8,267,163	8,991,042
Two Harbors, Minn.	7,676,523	9,631,235	6,608,616	7,414,003	12,116,346	10,535,909
Subtotal	60,379,383	55,404,432	48,694,453	61,444,856	72,880,345	73,436,384
Minor Harbors						
Bayfield Harbor, Wis.	17,804	19,693	14,309	26,211	20,187	94,782
La Pointe Harbor, Wis	4,272	4,402	4,321	4,349	117,524	85,918
Ontonagon Harbor, Mich.	85,740	95,035	265,763	302,063	235,198	159,711
Washington Harbor, Minn.	0	0	0	0	0	40
Grand Portage, Minn. *	0	0	0	0	0	40
Munising Harbor, Mich. *	0	0	0	0	0	23,425
Oak Island, Minn. *	0	0	0	0	0	331
Keweenaw Waterway, Mich.	241,163	102,993	52,257	107,430	82,718	78,397
Subtotal	348,979	222,123	336,650	440,053	455,627	442,644
Total-Lake Superior	60,728,362	55,626,555	49,031,103	61,884,909	73,335,972	73,879,028
Lake Michigan						
Northern Lake Michigan						
Major Harbors						
Escanaba, Mich. *	10,454,389	8,675,617	8,720,235	6,112,919	7,872,849	6,767,196
Green Bay Harbor, Wis.	2,422,674	2,295,721	2,199,701	1,431,203	1,640,057	1,546,870
Ludington Harbor, Mich.	1,174,955	1,075,051	720,904	894,477	1,151,604	1,179,200
Petoskey, Penn Dixie Harbor *						
Port Inland, Mich. *	2,221,396	2,283,960	2,638,166	3,173,394	3,384,389	3,458,287
Traverse City Harbor, Mich.	325,529	221,850	307,774	253,225	258,667	212,485
Subtotal	16,598,943	14,552,199	14,586,780	11,865,218	14,307,566	13,164,038
Minor Harbors						
Algoma Harbor, Wis.	10,125	203	0	0	0	0
Cedar River Harbor, Mich.	4,766	2,439	0	0	0	0
Charlevoix Harbor, Wis.	102,703	126,421	59,453	126,537	118,184	1,455,688
Frankfort Harbor, Mich.	71,586	42,213	69,774	62,881	62,317	72,361
Gladstone Harbor, Wis.	155,440	125,538	42,741	51,792	144,227	94,413
Kewaunee Harbor, Wis.	320,226	437,753	392,248	241,903	231,929	240,947
Mackinaw City Harbor, Mich.	130,180	133,825	142,175	167,301	245,889	186,301
Manistee Harbor, Mich.	262,650	263,360	241,275	244,663	244,663	324,698
Manistique Harbor, Mich.	13	113	9,286	28,174	27,295	0
Manitowoc Harbor, Wis.	274,549	190,593	304,382	176,241	112,036	217,849
Menominee Harbor, Mich-Wis	175,992	119,240	189,837	91,538	116,758	128,878
Pensaukee Harbor, Wis.	3,741	1,626	0	0	0	0
St. James (Beaver Island), Mich	8,739	4,319	2,165	3,398	4,540	3,535
Sturgeon Bay(LMSC) Wis.	102,194	195,083	469,644	53,881	10,430	2,866
Two Rivers Harbor, Wis.	13,225	18,295	5,105	8,942	0	0
St. Ignace, Mich.	0	0	0	0	0	25,515
Detroit Harbor, Wis.	6,438	5,082	6,220	8,961	5,446	6,025
Wells, Mich. *	0	0	0	0	0	57,044
Gills Rock, Wis. *	0	0	0	0	0	29
Northport, Wis.	0	0	0	0	0	5,996
Subtotal	1,642,567	1,666,103	1,934,305	1,266,212	1,323,714	2,822,145
Subtotal-Northern Lake Michigan	18,241,510	16,218,302	16,521,085	13,131,430	15,631,280	15,986,183

(Table 30 - Continued)

	1984	1985	1986	1987	1988	1989
Lake Michigan						
Southern Lake Michigan						
Major Harbors						
Buffington Harbor, [Gary] Ind.*	1,402,846	1,386,964	576,196	692,825	1,265,934	994,695
Burns Waterway Harbor, Ind.	8,790,770	8,178,641	6,749,674	7,093,196	7,468,121	8,695,318
Port Of Chicago, Ill.	23,813,368	22,610,102	24,330,497	20,705,271	22,893,740	23,445,821
Gary Harbor, Ind. *	5,880,321	6,945,966	3,698,910	5,880,321	8,635,444	8,305,159
Grand Haven Harbor, Mich.	1,358,439	1,455,412	1,377,201	1,388,086	1,423,935	1,333,190
Holland Harbor, Mich.	298,773	456,506	419,702	313,937	313,143	361,220
Indiana Harbor, Ind.	14,568,811	13,549,278	14,014,139	13,335,416	16,643,362	15,054,899
Milwaukee Harbor, Wis.	2,993,065	2,489,684	1,823,143	2,161,038	2,289,211	2,379,208
Muskegon Harbor, Mich.	1,303,734	773,581	1 192,780	1,201,746	1,543,778	1,876,856
St. Joseph Harbor, Mich.	330,042	390,330	432,818	492,392	462,847	385,508
Waukegan Harbor, Ill.	343,149	404,619	464,213	457,730	480,323	470,047
Subtotal	61,083,318	58,641,083	55,079,273	53,721,958	63,419,838	63,291,921
Minor Harbors						
Sheboygan, Wisc.	1,257,661	1,095,005	920,509	843,185	806,434	72,870
Kenosha Harbor, Wis.	42,011	60,377	37,759	55,932	17,659	6
Michigan City Harbor, Ind.	208	317	0	208	0	0
Port Washington Harbor, Wis.	382,645	241,281	293,363	127,370	185,624	172,672
Subtotal	1,682,525	1,396,980	1,251,631	1,026,695	1,009,717	245,548
Subtotal-Southern Lake Michigan	62,765,843	60,038,063	56,330,904	54,7748,653	64,429,555	63,537,469
Total-Lake Michigan	81,007,353	76,256,365	72,851,989	67,880,083	80,060,835	79,523,652
Lake Huron						
Major Harbors						
Alabaster Harbor, Mich. *	555,692	576,293	628,242	642,232	612,476	492,923
Alpena Harbor, Mich.	2,423,224	2,382,346	2,393,224	1,968,866	2,128,411	2,397,107
Calcite Mich. *	7,788,797	7,739,581	6,843,000	8,159,252	10,025,105	9,238,094
Stoneport, Mich. *	5,946,248	6,500,996	6,642,565	8,185,999	8,337,308	8,887,828
Drummond Island, Mich. *	1,090,809	1,187,254	1,300,619	1,515,950	535,012	819,870
Port Dolomite, Mich. *	2,257,934	2,043,655	1,722,313	2,856,328	4,149,564	3,635,510
Port Gypsum, Mich. *	322,298	365,562	449,942	430,751	408,320	457,102
Cheboygan Harbor, Mich.	117,231	86,553	112,564	142,044	162,210	143,436
Saginaw River,Mich.	2,541,884	3,902,669	3,917,116	4,342,102	4,570,652	4,673,985
Subtotal	23,044,117	24,786,909	24,009,585	28,243,524	30,929,058	30,745,855
Minor Harbors						
Harbor Beach, Mich.	41,972	34,596	109,951	102,278	193,307	97,534
Harrisville Harbor, Mich.	85,441	0	0	0	0	0
Mackinac Harbor, Mich.	16,790	26,232	36,754	24,457	61,321	16,002
Sault. Ste. Marie, Mich.	84,216	52,980	112,222	61,913	69,717	29,377
Detour, Mich.	256	92	0	0	733	2,593
Subtotal	228,675	113,900	258,927	188,648	325,078	145,506
Total-Lake Huron	23,272,792	24,900,809	24,268,512	28,432,172	31,254,136	30,891,361
St Clair And Detroit Rivers						
Major Harbors						
Port Of Detroit, Mich.	17,530,626	15,612,344	15,219,322	14,129,844	15,331,351	20,700,867
Marysville, (St. Clair River)	353,285	73,768	210,431	440,089	221,264	558,896
Marine City, Mich.(St Clair)	350,696	270,747	381,656	419,253	383,184	327,503
Port Huron, Mich.(St. Clair)	578,704	324,843	519,010	539,053	954,650	1,034,052
St. Clair, Mich.(St Clair River)	5,379,966	6,176,971	8,608,164	8,449,794	8,212,259	5,756,194
Total-St. Clair & Detroit Rivers	24,193,277	22,458,673	24,938,583	23,978,033	25,102,708	28,377,512

(Table 30 - Continued)

	1984	1985	1986	1987	1988	1989
Lake Erie						
Major Harbors						
Ashtabula Harbor, Ohio	9,243,475	7,039,128	7,163,593	8,888,069	10,335,305	10,322,455
Port of Buffalo, New York	1,854,266	1,779,481	1,628,169	1,423,205	1,334,608	2,145,188
Cleveland Harbor, Ohio	12,920,708	13,767,174	12,188,278	13,914,047	14,550,876	14,687,619
Conneaut Harbor, Ohio	12,660,783	9,148,003	7,675,248	7,046,570	10,220,234	8,889,518
Erie Harbor, Pa.	828,094	965,589	834,141	971,320	1,002,418	733,506
Fairport Harbor, Ohio	1,995,097	2,317,777	2,492,551	2,077,272	2,211,581	2,634,271
Huron Harbor, Ohio	2,509,263	1,950,106	262,720	529,031	522,743	590,085
Lorain Harbor, Ohio	9,884,246	9,426,024	11,426,688	14,372,412	17,475,549	14,568,175
Marblehead, Ohio *	785,750	581,925	849,375	1,098,332	1,013,013	912,141
Monroe Harbor, Mich.	2,398,740	792,884	622,757	1,177,883	1,122,552	1,489,864
Sandusky Harbor, Ohio	4,789,730	4,585,990	4,134,889	3,319,468	4,831,214	4,485,328
Toledo Harbor, Ohio	20,836,636	18,400,468	17,818,554	16,211,727	14,741,752	14,805,833
Sub-Total	80,706,788	70,754,549	67,096,963	71,029,336	79,361,845	76,263,983
Minor Harbors						
Barcelona Harbor, N.Y.	26,010	56	0	0	0	0
Kellys Island, Ohio	3,469	4,587	7,793	6,451	18,049	6,256
Port Clinton Harbor, Ohio	17,614	20,802	19,077	18,604	5,320	15,316
Put-In-Bay Harbor, Ohio	6,072	4,581	4,765	11,761	1,149	1,704
Catawba Is., Ohio	0	0	0	0	0	1,795
North Bass Is.,Ohio	0	0	0	0	0	856
Middle Bass Is., Ohio	0	0	0	0	0	104
Sub-Total	53,165	30,026	31,635	36,816	24,518	26,031
Total-Lake Erie	80,759,953	70,784,575	67,128,598	71,066,152	79,386,363	76,290,014
Lake Ontario						
Major Harbors						
Oswego Harbor, New York	473,657	525,076	482,648	448,142	530,735	745,842
Sub-Total	473,657	525,076	482,648	448,142	530,735	745,842
Minor Harbors						
Rochester Harbor, New York	238,591	282,170	230,330	243,045	237,111	224,088
Sub-Total	238,591	282,170	230,330	243,045	237,111	224,088
Total-Lake Ontario	712,248	807,246	712,978	691,187	767,846	969,930
St. Lawrence River						
Minor Harbors						
Ogdensburg Harbor, New York	63,375	51,066	116,867	139,731	103,690	135,252
Total-St Lawrence River	63,375	51,066	116,867	139,731	103,690	135,252
TOTAL GREAT LAKES	270,737,360	250,885,289	239,048,630	254,072,267	290,066,749	290,066,749

Source: Waterborne Commerce Of The United States, Part 3, Waterways And Harbors, Great Lakes. Calendar Years 1984, 1985, 1986, 1987, 1988, and 1989.

* denotes a private harbor.

TABLE 31. SUMMARY CLASSIFICATION OF GREAT LAKES HARBORS BY DEPTH

Lake	Less than 15 ft.	15 ft. to 20 ft.	Greater than 20 ft.	All Harbors
		Number of Harbors		
Superior	5	2	8	15
Michigan	9	5	26	40
Huron 1/	2	1	16	19
Erie	7	0	12	19
Ontario 2/	0	0	3	3
Total	23	8	65	96
		Gross 1989 Tonnages by Lake		
Superior	181,111	183,136	73,514,781	73,879,028
Michigan	201,886	923,479	77,728,435	78,853,800
Huron 1/	2,593	457,102	58,809,178	59,268,873
Erie	26,031	0	76,263,983	76,290,014
Ontario 2/	0	0	1,105,182	1,105,182
Total	411,621	1,563,717	287,421,559	289,396,897

1/ Lake Huron includes harbors in the St. Clair - Detroit River system.

2/ Lake Ontario includes the port of Ogdensburg, N.Y. which is situated on the St. Lawrence River.

TABLE 32. RANK ORDER OF GREAT LAKES HARBORS AND PORTS BY TONNAGE, 1989

Rank	Harbor/Port Name	Tons
1.	Duluth-Superior Harbor, Minn. & Wisc.	40,802,541
2.	Port Of Chicago, Ill.	23,445,821
3.	Port Of Detroit, Mich.	20,700,867
4.	Toledo Harbor, Ohio	14,805,833
5.	Cleveland Harbor, Ohio	14,687,619
6.	Lorain Harbor, Ohio	14,568,175
7.	Indiana Harbor, Ind.	14,385,047
8.	Presque Isle Harbor, Mich.	12,155,757
9.	Two Harbors, Minn.	10,535,909
10.	Ashtabula Harbor, Ohio	10,322,455
11.	Calcite Mich. *	9,238,094
12.	Taconite Harbor, Minn. *	8,991,042
13.	Conneaut Harbor, Ohio	8,889,518
14.	Stoneport, Mich. *	8,887,828
15.	Burns Waterway Harbor, Ind.	8,695,318
16.	Gary Harbor, Ind. *	8,305,159
17.	Escanaba, Mich. *	6,767,196
18.	St. Clair, Mich. (St Clair R.)	5,756,194
19.	Saginaw River, Mich.	4,673,985
20.	Sandusky Harbor, Ohio	4,485,328
21.	Port Dolomite, Mich. *	3,635,510
22.	Port Inland, Mich. *	3,458,287
23.	Fairport Harbor, Ohio	2,634,271
24.	Alpena Harbor, Mich.	2,397,107
25.	Milwaukee Harbor, Wisc.	2,379,208
26.	Port of Buffalo, New York	2,145,188
27.	Muskegon Harbor, Mich.	1,876,856
28.	Green Bay Harbor, Wisc.	1,546,870
29.	Monroe Harbor, Mich.	1,489,864
30.	Charlevoix Harbor, Wisc.	1,455,688
31.	Grand Haven Harbor, Mich.	1,333,190
32.	Ludington Harbor, Mich.	1,179,200
33.	Port Huron, Mich. (St. Clair)	1,034,052
34.	Buffington Harbor, [Gary] Ind.*	994,695
35.	Marblehead, Ohio *	912,141
36.	Drummond Island, Mich. *	819,870
37.	Marquette Harbor, Mich.	770,414
38.	Oswego Harbor, New York	745,842
39.	Erie Harbor, Pa.	733,506
40.	Huron Harbor, Ohio	590,085
41.	Marysville, St. Clair River	558,896
42.	Alabaster Harbor, Mich. *	492,923
43.	Waukegan Harbor, Ill.	470,047
44.	Port Gypsum, Mich. *	457,102
45.	St. Joseph Harbor, Mich.	385,508
46.	Holland Harbor, Mich.	351,220

(Table 32 - Continued)

Rank	Harbor/Port Name	Tons
47.	Marine City, Mich. (St Clair)	327,503
48.	Manistee Harbor, Mich.	324,698
49.	Kewaunee Harbor, Wisc.	240,947
50.	Rochester Harbor, New York	224,088
51.	Manitowoc Harbor, Wisc.	217,849
52.	Traverse City Harbor, Mich.	212,485
53.	Mackinaw City Harbor, Mich.	186,301
54.	Port Washington Harbor, Wisc.	172,672
55.	Ontonagon Harbor, Mich.	159,711
56.	Cheboygan Harbor, Mich.	143,436
57.	Ogdensburg, N.Y.	135,252
58.	Menominee Harbor, Mich.-Wisc.	128,878
59.	Ashland Harbor, Wisc.	120,653
60.	Harbor Beach, Mich.	97,534
61.	Bayfield Harbor, Wisc.	94,782
62.	Gladstone Harbor, Wisc.	94,413
63.	La Pointe Harbor, Wisc.	85,918
64.	Keweenaw Waterway, Mich.	78,397
65.	Sheboygan, Wisc.	72,870
66.	Frankfort Harbor, Mich.	72,361
67.	Silver Bay, Minn. *	60,068
68.	Wells, Mich. *	57,044
69.	Sault. Ste. Marie, Mich.	29,377
70.	St. Ignace, Mich.	25,515
71.	Munising Harbor, Mich. *	23,425
72.	Mackinac Harbor, Mich.	16,002
73.	Port Clinton Harbor, Ohio	15,316
74.	Kellys Island, Ohio	6,256
75.	Detroit Harbor, Wisc.	6,025
76.	Northport, Wisc.	5,996
77.	St. James (Beaver Island), Mich.	3,535
78.	Sturgeon Bay (LMSC) Wisc.	2,866
79.	Detour, Mich.	2,593
80.	Catawba Is., Ohio	1,795
81.	Put-In-Bay Harbor, Ohio	1,704
82.	North Bass Is., Ohio	856
83.	Oak Island, Minn. *	331
84.	Middle Bass Is., Ohio	104
85.	Grand Portage, Minn. *	40
86.	Washington Harbor, Minn.	40
87.	Gills Rock, Wisc. *	29
88.	Kenosha Harbor, Wisc.	6
89.	Pensaukee Harbor, Wisc.	0
90.	Barcelona Harbor, N.Y.	0
91.	Manistique Harbor, Mich.	0
92.	Two Rivers Harbor, Wisc.	0
93.	Harrisville Harbor, Mich.	0

(Table 32 - Continued)

Rank	Harbor/Port Name	Tons
94.	Cedar River Harbor, Mich.	0
95.	Algoma Harbor, Wisc.	0
96.	Michigan City Harbor, Ind.	0

* denotes private harbor.

TABLE 33. TONNAGE TRANSPORTED THROUGH PRIVATE HARBORS ON THE UNITED STATES SIDE OF THE GREAT LAKES, 1989

	Tons
Lake Superior	9,074,906
Silver Bay, Minn.	60,068
Taconite Harbor, Minn.	8,991,042
Munising Harbor, Mich.	23,425
Grand Portage, Minn.	40
Oak Island, Minn.	331
Lake Michigan	19,582,410
Buffington Harbor, (Gary) Ind.	994,695
Escanaba, Mich.	6,767,196
Gary Harbor, Ind.	8,305,159
Port Inland, Mich.	3,458,287
Wells, Mich.	57,044
Gills Rock, Wisc.	29
Lake Huron	23,531,327
Alabaster Harbor, Mich.	492,923
Calcite, Mich.	9,238,094
Drummond Island, Mich.	819,870
Port Dolomite, Mich.	3,635,510
Stoneport, Mich	8,887,828
Port Gypsum, Mich.	457,102
Lake Erie	912,141
Marblehead, Ohio	912,141
Lake Ontario	0
Total Great Lakes	53,100,784

"commercial harbors". Those commercial harbors include harbors built and maintained by private interests as well as Corps of Engineers projects.

Technically, Corps of Engineers harbor projects are authorized for either "commercial navigation" or "recreation navigation" purposes. In practice, many commercial navigation projects have a combination of both commercial and recreation uses. Over time, recreation has become the principal or only use of some Great Lakes projects. For the purposes of this report, harbors having no cargo receipts or shipments are referred to as recreation harbors; the term commercial harbor is used if statistics show any commercial use.

In some cases, usually for large metropolitan areas, the term "port", as opposed to "harbor", is used. The basic concept of a harbor is that it is a location that provides safe shelter to ships. While the terms harbor and port are sometimes used interchangeably, in the Gray Book the term port is used when referring to two or more harbors in one general area -- usually in one metropolitan area. Thus the statistics refer to the **Ports** of Chicago and Detroit but they refer to Cleveland **Harbor**.

HISTORICAL TRAFFIC PERSPECTIVE

Historical data on tonnages transported at each of the 96 commercial harbors on the Great Lakes in the United States are presented in Table 30. The data are for the period 1984-1989. While data could have been provided for a longer period of time, little would have been gained as historical data reflects historical conditions and historical conditions can rarely be reinstated. This is particularly true for waterborne shipments across the Great Lakes as the 1982-83 recession produced a restructuring of the U.S. steel industry that has become permanent. The seven year period contained in the table is adequate to provide a snapshot of current trends.

With 96 harbors it is difficult to decide which harbors have experienced "significant" change in their traffic. For the sake of brevity, only a few of the significant changes are commented upon.

Among the Lake Superior iron ore shipping ports there is a difference in the performance of Duluth-Superior and the taconite shipping harbors of Taconite Harbor and Two Harbors. Whereas Duluth-Superior lost significant tonnages in 1985 and 1986, the taconite shipping harbors experienced reasonable but not consistent growth. Also notable is the termination of shipments from Silver Bay in 1986; substantial shipments were restarted in 1990.

On Lake Michigan the most notable change is the 1,200% increase in tonnages at Charlevoix from the 1984-88 period to 1989. As Charlevoix is the location of a cement plant, this probably reflects a change in the method of transporting cement at that harbor. Almost as notable is the persistent decline in tonnages at Sheboygan, Wisconsin. Escanaba, Wisc., the only iron ore shipping port on the Lake Michigan, also experienced a substantial decline in shipments.

On Lake Huron and the St. Clair - Detroit River System tonnages varied across individual harbors. The most notable changes are the large decline at Cheboygan, Mich. and the growth at Saginaw River. The latter was persistent across each of the seven years.

On Lake Erie the most notable change has been large declines at Huron and Toledo and substantial growth at Lorain.

HARBORS BY COMMODITY

The basic spatial flows of commodities transported across the Great Lakes have been discussed in Chapter 5 -- Commodity Flows. This section briefly discusses individual harbors from which and to which the major commodities are shipped.

The best display of harbors organized by commodities shipped and received are two maps published by the Lake Carriers Association. These maps have been reproduced with the permission of the Association. Fig. 24 is the map of Great Lakes Loading (Shipping) Ports. Fig. 25 is the map of Great Lakes Receiving Ports. Although the Association calls the individual locations ports, most are technically harbors.

Loading (Shipping) Ports

Most of the shipping ports presented in Fig. 24 have been mentioned in the discussion of commodities presented in Chapter 5. Rather than repeat that information, only deviations or exceptions are commented upon in this section.

With respect to shipments of iron ore there is confusion between Marquette and Presque Isle. Both harbors are located on the north shore of the Upper Peninsula of Michigan, about 15 miles apart. Because they are physically close and because there are very few communities along the north shore of the Upper Peninsula of Michigan, there is a tendency to interchange the two. This is apparently what has been done in the listing of iron ore loading ports. In actuality no iron ore is currently shipped from Marquette but large tonnages are shipped from Presque Isle. Note that Presque Isle is not listed on the map in Fig. 24.

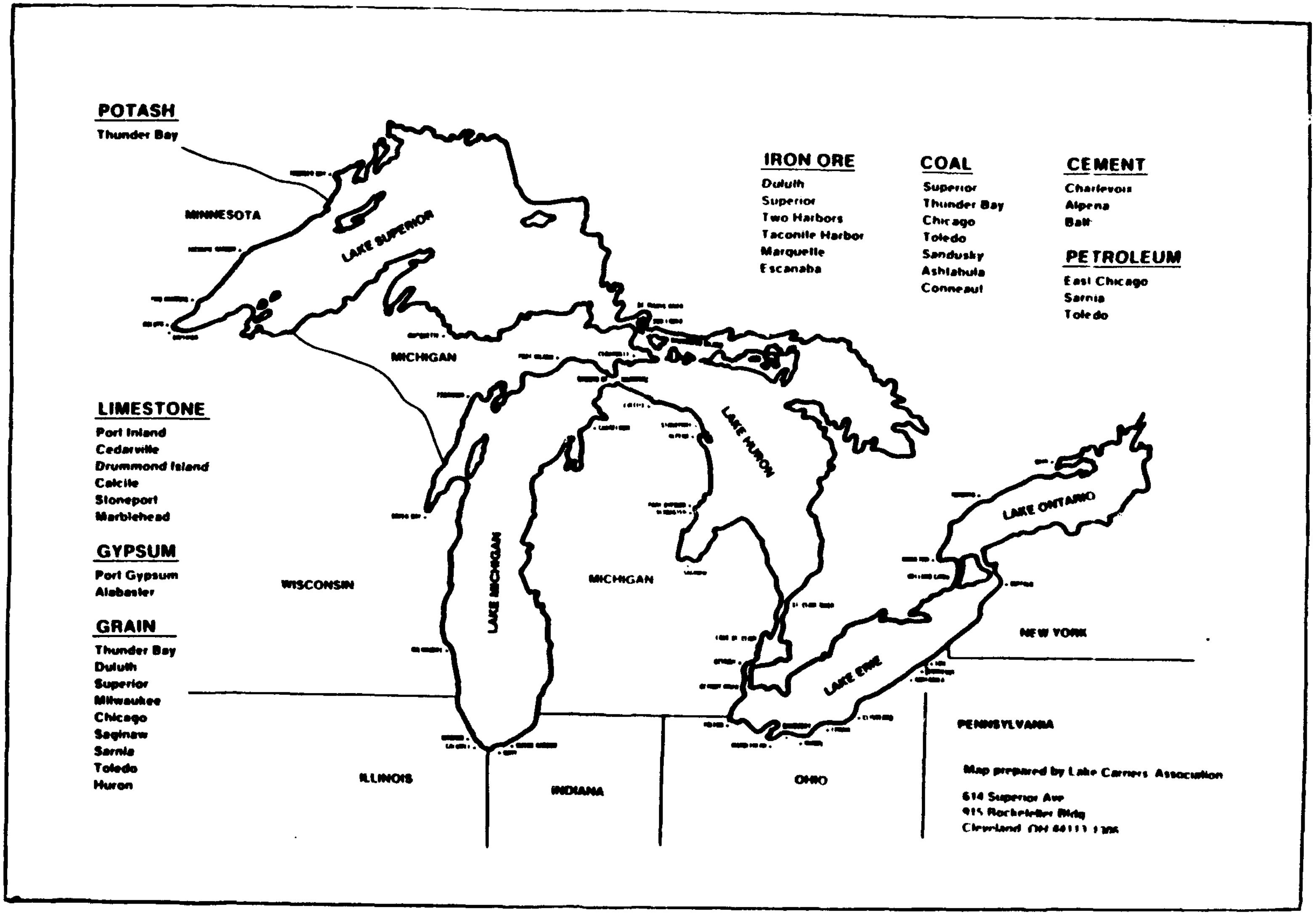


FIGURE 24. GREAT LAKES LOADING PORTS

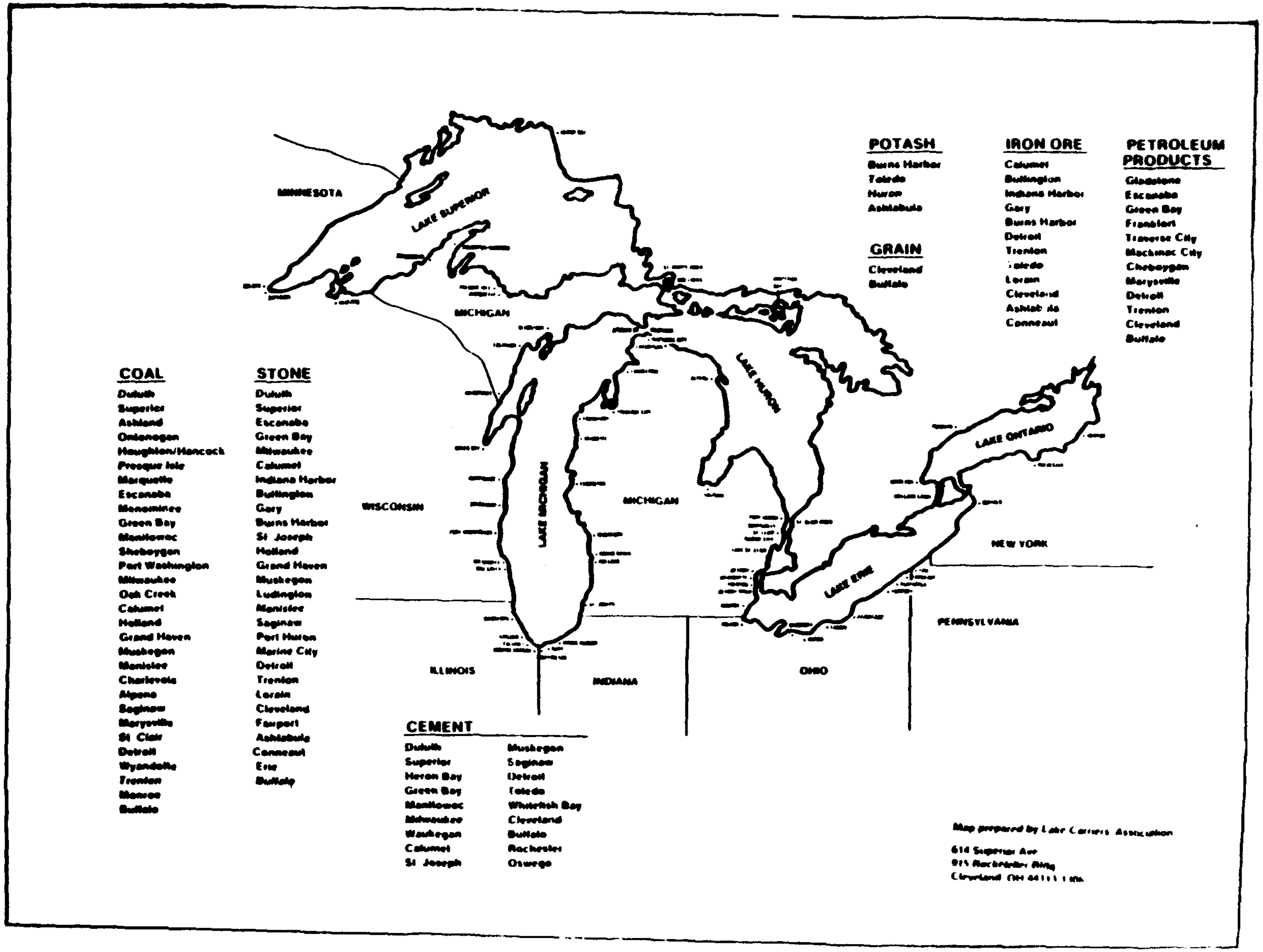


FIGURE 25. GREAT LAKES RECEIVING PORTS

A similar situation exists in the list of limestone loading ports. Here the confusion is between Cedarville and Port Dolomite. Cedarville is the actual location of the dock, which in the Corps of Engineers' Grey Book, is referred to as Port Dolomite.

Another similar situation exists in the list of petroleum loading ports. East Chicago, Ind. is synonymous with Indiana Harbor. The former is the local name for the harbor that is listed in the Grey Book as Indiana Harbor.

Receiving Ports

A comparison of Figs. 24 (Loading Ports) and 25 (Receiving Ports) shows that there are more receiving harbors than shipping harbors. This is true for each commodity listed except grain. For grain there is only one receiving port on the Great Lakes (U.S. and Canada -- Buffalo. Fig. 25 needs updating since grain is no longer received at Cleveland.

Iron ore is received directly at steel mills in the Chicago area, and at Detroit, Cleveland and Lorain. Chicago area harbors (Calumet, Buffington, Indiana Harbor, Gary and Burns Harbor) receive the largest volume. Detroit, Cleveland and Lorain receive lesser amounts. Because about half of the iron ore received at Lorain is reshipped in smaller vessels to Cleveland, there is substantial double counting at the aggregate lake or system level in the receipts of iron ore at these two harbors. Toledo, Conneaut and Ashtabula, which do not possess steel mills, also receive substantial volumes of iron ore. The ore received at these three Lake Erie harbors is transshipped by rail to inland, midwestern steel mills.

Coal is received at numerous harbors. However, most coal is shipped to three harbors in southeastern Michigan. The three harbors of St. Clair, Detroit and Monroe received more than 10.0 million tons of coal in 1989. This is largely low sulfur, Western coal shipped from Duluth-Superior to Detroit Edison's thermal electric plants at these three locations.

Limestone has several uses: it is mixed with iron ore to produce flux pellets; it is a charge in the blast furnace; it is a raw material in the cement industry; it is the source of aggregate in the manufacturing of concrete at local ready-mix plants; and it is an input in the process of extracting sugar from sugar beets. Thus, limestone is shipped to many harbors on the lakes. The harbor that receives the largest volume of limestone is Saginaw River in the lower Peninsula of Michigan. Other major harbors are the iron ore ports at the "Head of the Lakes" and the steel producing centers of Chicago, Detroit and Cleveland.

Cement is produced at three locations along the Great Lakes (Charlevoix and Alpena, Mich. and Bath, Ont.), but it is widely distributed by water to numerous Great Lakes cities. Since it is the basic material used in the construction industry, it is distributed to all metropolitan areas along the lakes. Chicago, the largest metropolitan center on the lakes, receives the largest amount, but Detroit and Cleveland also receive substantial amounts.

The spatial pattern of receipts of petroleum products is similar to that of coal, limestone and cement; they are received at numerous harbors with the largest volumes being received in the larger metropolitan centers of Detroit, Cleveland and Buffalo. The metropolitan Chicago area is not a receiving port as it is the principal petroleum products shipping port on the lakes. The remaining receiving ports receive relatively minor amounts of petroleum products.

Toledo is the dominant harbor that receives potash.

HARBORS BY DEPTH

The depth of a harbor is primarily of interest because it controls the size of ship that may access the harbor. In turn, the size of the vessel directly affects the cost of transporting a commodity. Additionally, Federal regulations specify that the cost of constructing new facilities at existing Federal harbors, or the construction of a new Federal harbor, must be cost shared between the Federal Government and a nonfederal sponsor. The cost sharing formula is determined by the depth of harbor.

Unfortunately the concept of harbor depth is not as simple as it might seem. An initial source of potential confusion is the definition of harbor (channel) depth. The Corps of Engineers recognizes three definitions of harbor (channel) depth. Authorized Depth is the depth(s) specified in the congressional authorization. Construction Depth is the depth(s) to which the harbor (channel) was initially constructed; harbors are not always constructed to the authorized depth. Maintenance Depth is the depth the Corps attempts to provide through periodic dredging.

Additionally it is not uncommon for a harbor to have multiple channels. It also is very common for a channel to have multiple depths. Generally channel depth decreases as one proceeds into or upstream in a harbor. Federal harbors are usually assigned a depth based upon the depth in their outer harbor.

Data on project depths for the 96 commercial harbors on the United States side of the Great Lakes, as well as the tonnage of traffic handled at each harbor in 1989, are provided in Appendix A. Table 31 is a summary of that data. For three depth

categories (less than 15 feet, 15 feet to 20 feet, and greater than 20 feet), it presents the number of harbors and the 1989 tonnage at all harbors in the specified depth category. The data on harbor depths for Federal harbors were obtained from the staff of the Institute for Water Resources (IWR) and from individual Corps of Engineers Districts. For Federal harbors the depths presented represent the authorized depth in the outer harbor. For private harbors depths are approximations of harbor depth obtained from information on individual docks provided in the 1991 issue of Greenwood's Guide to Great Lakes Shipping.

Most Great Lakes harbors in the U.S. possess depths in excess of 20 feet. Of the 96 commercial harbors on the lakes 23 are at a depth less than 15 ft., 8 are at a depth between 15 and 20 ft., and 65 are at a depth in excess of 20 ft. Harbors with depths of 20 ft. or less are of negligible significance to commercial navigation on the lakes. Of the 289.4 million tons transported to and from the 96 harbors in 1989 only 2.0 million tons (0.68%) passed through harbors whose depth was 20 ft. or less.

INDIVIDUAL HARBORS

A rank order listing has been prepared of U.S. commercial harbors on the Great Lakes (Table 32). The harbors are ranked in terms of the total tonnages received and shipped in 1989.

A brief discussion is presented of the three leading harbors on the United States side of the Great Lakes: Duluth-Superior, Chicago and Detroit.

Duluth-Superior Harbor

Duluth-Superior is the western-most harbor on the Great Lakes; it is the "Head of the Lakes". Duluth, Minn. is the larger of the two communities. Though it encompasses the harbors of the two communities, it is considered one harbor. It includes Superior Bay and its tributaries, St. Louis Bay and St. Louis River, and Allquez Bay. It is the most prominent harbor on the Great Lakes, handling 40.8 million tons in 1989. It is primarily a shipping (point of origin) harbor; less than 10% of its tonnages consist of receipts and imports. Though most shipments are destined for United States harbors, a significant amount (more than 6.0 million tons) represents international traffic.

Two commodities are dominant in Duluth-Superior: iron ore and coal. About one-half of the harbor's total tonnage comes from shipments of iron ore; about one-quarter comes from shipments of coal. The iron ore originates at the nearby Mesabi Range from which it is transported by rail to Duluth-Superior. The coal is

Western coal originating in the Powder River Basin of Wyoming and Montana; most comes from Montana. It is transported by unit trains to Superior Midwest Energy's terminal at Superior. From there the coal is transported down the lakes, principally to thermal electric plants operated by Detroit Edison.

Shipments of grain, including soybeans, account for about 10% to 15% of the tonnage handled by the harbor. Most of this is wheat produced in the Spring Wheat Belt of the Northern Great Plains. The only other commodity handled in large quantity is limestone.

Port of Chicago

The Port of Chicago is the second most prominent harbor on the United States side of the lakes but it is a distant second. In 1989 it handled 23.4 million tons. The Port of Chicago includes the following harbors: Chicago Harbor, Chicago River Main and North Branch, Chicago River South Branch, Chicago Sanitary and Ship Canal, Calumet-Sag Calumet, Ill., and Calumet Harbor and River, Ind. & Ill. The Port of Chicago is connected to the Mississippi River via the Illinois River. Of all its constituent harbors, the Calumet Harbor and River, Ill. & Ind. is the most prominent; it accounted for almost 12 of the 23.4 million tons handled by the port in 1989.

With the Port of Chicago being as geographically dispersed as it is and with Metropolitan Chicago being a major industrial center, the composition of traffic in the port is quite diverse and includes numerous commodities. This is in marked contrast to Duluth-Superior. Most of the traffic is domestic U.S. traffic though slightly more than four million tons were international traffic in 1989. The more prominent commodities include: grain and soybeans, iron ore, coal, sand & gravel, nonmetallic minerals, chemicals, petroleum products, cement, and iron & steel products. The Port of Chicago is unique on the Great Lakes in that it has a significant general cargo traffic.

Port of Detroit

The Port of Detroit ranks third among American Harbors on the Great Lakes; it handled 20.7 million tons in 1989. The Port of Detroit includes the following harbors: Detroit Harbor, Rouge River, Ecorse, Wyandotte, Riverview and Trenton.

To a great extent, the Port of Detroit is a characteristic, though somewhat large, harbor/port on the Great Lakes. Most (about 85%) of its traffic is domestic. Three commodities dominate: iron ore (about 40%), coal (about 20%) and limestone (about 15%). Significant but lesser quantities of petroleum products, cement, and steel products are transported through the port.

PRIVATE COMMERCIAL HARBORS

There are 18 private commercial harbors on the Great Lakes (Table 33). While there are many other private harbors on the Great Lakes, they are not commercial harbors. A private commercial harbor is a commercial harbor that is owned and operated by a private entity -- usually a corporation. By definition, private harbors receive no federal funds. They are entirely maintained by the owner(s) of the harbor.

In general the private harbors on the Great Lakes are: (1) harbors owned by mining companies to load iron ore for shipment; (2) harbors owned by steel companies to receive raw materials; (3) harbors owned by stone companies for shipment of stone (limestone and gypsum); and, (4) a number of very small harbors apparently used to transport general merchandise to/from islands. Private harbors are important on the U.S. side of the lakes as they originate and receive a large volume of traffic on the lakes. In 1989 the 18 harbors transported (shipped and received) 53.1 million tons, which was 18.3% of all freight transported on the lakes in that year.

CHAPTER 7

OPERATIONS & MAINTENANCE

The cost to the Federal Government of operating and maintaining Great Lakes harbor and waterway projects is substantial. This chapter will present an overview of the Federal expenditures for operation and maintenance (O&M). Additionally, the recently implemented Harbor Maintenance Fee is discussed.

O&M EXPENDITURES

Most Federal O&M expenditures are spent to maintain channels and physical infrastructure (breakwalls, jetties, etc.). Federal funds are also expended to operate the locks in the United States portion of the Great Lakes -- the Soo Locks, the Black Rock Lock in Buffalo and the Chicago Harbor Lock. Total Federal expenditures for O&M on the Great Lakes in **current dollars** for the period 1977 to 1990 are presented in Table 34. The same data in **constant 1990 dollars** are presented in Table 35. Figure 26 is a graph of the constant dollar data presented in Table 35.

The constant dollar data set presented in Table 35 is preferred as it eliminates the inflationary effect that inevitably accrues to a time series set of data. Unless otherwise stated, the following comments are based on the constant dollar data. Total O&M expenditures have varied substantially between 1977 and 1990. In constant 1990 dollars the highest value, $136.1 million, was expended in 1978; the lowest value, $63.1 million, was expended in 1990.

Several factors affected the variation in total O&M expenditures. A major factor was the implementation of the Corps' Confined Disposal Facility (CDF) program for the inland navigation system, including the Great Lakes, which was authorized by Public Law 91-611. For the Great Lakes, the 1977-79 period expenditures for dike disposal construction averaged $32.5 million (current dollars). Expenditures had to be at this elevated level until the confined disposal facility areas were constructed, because dredging of contaminated channels had to be deferred since there were no environmentally secure sites to deposit the contaminated sediments. By 1984-86, annual expenditures for this program had declined to $5.1 million.

Another factor responsible for a significant proportion of the variation in O&M expenditures was variation in major rehabilitation. Expenditures for this purpose were minimal in the 1977-79 period. In the 1984-86 period, major rehabilitation expenditures averaged $6.1 million (current dollars). For 1990-92, major rehabilitation expenditures are once again projected to be minimal.

TABLE 34. TOTAL OPERATIONS AND MAINTENANCE EXPENDITURES BY LAKE, 1977 - 1990

($1,000 current)

Lake	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Onario	1,530	1,602	752	709	2,319	1,374	1,665	2,188	808	1,843	1,477	1,701	133	1,375
Erie1/	32,753	38,050	47,636	41,424	38,887	35,302	44,434	32,861	32,861	25,405	20,902	23,183	18,110	20,665
Huron	15,280	18,017	10,885	13,697	13,840	13,764	12,706	15,709	15,709	14,581	15,347	26,948	16,225	16,959
Michigan	9,952	13,148	14,540	8,747	16,465	16,295	19,468	22,600	18,007	24,981	19,670	24,856	30,111	15,883
Superior2/	2,716	3,969	3,675	2,720	3,721	2,985	3,094	4,252	7,591	10,219	10,868	5,726	8,684	8,212
Total	62,231	74,796	77,488	67,297	75,232	69,720	81,367	74,976	74,976	77,029	68,264	82,414	73,263	63,094

Source:

1/ Lake Erie includes the connecting channels for the St. Clair - Detroit River systems.

2/ Lake Superior includes the connecting channels for the Straits of Mackinac and St. Marys River.

TABLE 35. TOTAL OPERATIONS AND MAINTENANCE EXPENDITURES FOR THE GREAT LAKES BY LAKE, 1977 - 1990

($1,000 constant)

Lake	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Onario	2,984	2,916	1,256	1,085	3,247	1,814	2,115	2,669	962	2,138	1,654	1,837	140	1,375
Erie1/	63,868	69,251	79,552	63,379	54,442	46,599	56,431	41,247	39,105	29,470	23,410	25,038	19,016	20,665
Huron	29,796	32,791	18,178	20,956	19,376	18,168	16,137	22,449	18,694	16,914	17,189	29,104	17,036	16,959
Michigan	19,406	23,929	24,282	13,383	23,051	21,509	24,724	27,572	21,428	28,978	22,030	26,844	31,617	15,883
Superior2/	5,296	7,224	6,137	4,162	5,209	3,940	3,929	5,187	9,033	11,854	12,171	6,184	9,118	8,212
Total	121,360	136,111	129,405	102,965	105,325	92,030	103,336	99,124	89,222	89,354	78,455	89,007	76,927	63,094

Source:

1/ Lake Erie includes the connecting channels for the St. Clair - Detroit River systems.

2/ Lake Superior includes the connecting channels for the Straits of Mackinac and St. Marys River.

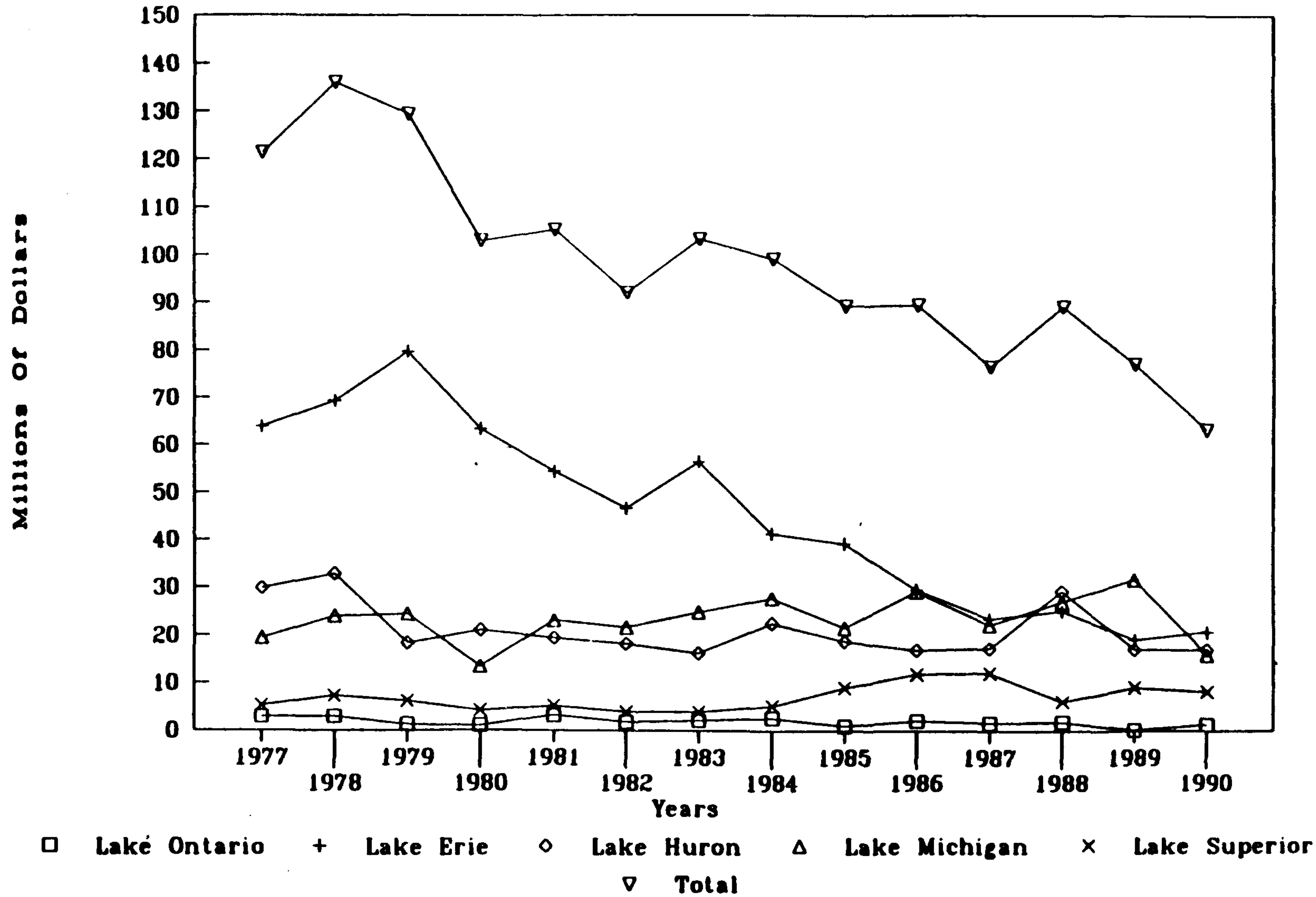


FIGURE 26. MAINTENANCE EXPENDITURES BY LAKE, 1977-1990

There is one clear trend in the data; less has been spent as time has progressed. This is most clearly shown in Table 36 which presents the average amount expended per year in each of three, three-year intervals: 1977-79, 1984-86 and 1988-90. Total O&M expenditures average $129.0 million (constant 1990 dollars) per year in 1977-79, $92.6 million per year in 1984-86 and $76.3 million in 1990-92.

Three of the five Great Lakes -- Erie, Ontario and Huron -- experienced a decline in total O&M expenditures through each of the three periods. The decline has been most notable in Lake Erie where total O&M expenditures declined from a level of $70.9 millon in 1977-79, to $21.6 million in 1988-90. The latter value is less than a third (30.5%) of the former value. Total O&M expenditures in 1988-90 on Lakes Ontario ($1.1 million) and Huron ($21.0 million) averaged 46.8% and 78.1%, respectively, of the 1977-79 average annual expenditures.

TABLE 36. TOTAL FEDERAL O&M EXPENDITURES, THREE YEAR ANNUAL AVERAGES, 1977-79, 1984-86, AND 1988-90
(Thousands of Constant 1990 Dollars)

Lake	1977 - 1979	1984 - 1986	1988 - 1990
Ontario	2,385	1,923	1,117
Erie 1/	70,890	36,607	21,573
Huron 2/	26,922	19,352	21,033
Michigan	22,539	25,993	24,781
Superior	6,219	8,691	7,838
Total Great Lakes	128,955	92,567	76,343

Source: COEMIS Historical Data on Annual Maintenance Costs, Army Corps of Engineers, Washington, D.C.

1/ Expenditures on the St. Clair - Detroit River connecting channels that connect Lakes Huron and Erie are reported in Lake Erie.
2/ Expenditures on the St. Marys River and the Soo Locks, the connecting channel from Lake Superior to Lake Huron, are included in Lake Huron.

The amounts expended on Lakes Michigan and Superior have increased over the 14 years, but the increase has not been consistent over time. Total O&M expenditures on Lake Michigan increased from an average annual level of $22.5 million in 1977-79 to $26.0 million in 1984-86, only to decline to $24.8 million in 1990-92. Total O&M expenditures on Lake Superior increased from an average annual level of $6.2 million in 1977-79 to $8.7 million in 1984-86, only to decline to $7.8 million in 1988-90.

The extent to which the substantial decline in O&M expenditures have affected commercial navigation on the Great Lakes is not known. Commercial navigation on the lakes responds to economic conditions of the industries that use the commodities transported across the lakes. However, declines in O&M expenditures that reflect lesser levels of maintenance, particularly lesser amounts of dredging, could affect the cost of transporting commodities. In turn, increased transportation costs could affect the economic viability of some of the industries situated along the shores of the Great Lakes. At a minimum the substantial declines reflected in the data should be the subject of some concern. An additional concern is the level of expenditures for confined disposal facilities; this will be addressed in a Chapter Eight.

Data on total O&M expenditures for each harbor on each of the five Great Lakes for the years 1977 to 1992 are presented in Appendix B. The data for 1991 and 1992 are budgetary forecasts. This data was obtained from the Corps of Engineers' COEMIS database -- Corps of Engineers Management Information System.

DISAGGREGATED 1990 O&M DATA.

The total O&M expenditure data presented above may be disaggregated by "purpose item". Using reports obtained from the three Great Lakes Army Corps of Engineer Districts (Buffalo, Chicago and Detroit), data on total Federal O&M expenditures has been disaggregated into three "purpose items" -- normal maintenance, major rehabilitation and diked disposal. The 1990 data are presented for each harbor in each lake in Appendix C. A summary of that data is presented in Table 37.

The data in Table 37 are presented by "purpose item" for each of the five Great Lakes and for the "Connecting Rivers and Channels". The latter are the physical connections between the lakes. They include: (1) the St. Marys River and the Soo Locks; (2) The Straits of Mackinac; and, (3) the St. Clair - Detroit River System. The fourth interconnection, the Welland Canal, which connects Lakes Erie and Ontario, is excluded because it is operated and maintained by Canada. As the Straits of Mackinac is a natural waterway and requires little maintenance, "Connecting Rivers and Channels" effectively refers to the St. Marys River with the Soo Locks, and the St. Clair - Detroit River System.

Expenditures in the connecting channels have been netted out of the lake with which the Corps traditionally associates them - St. Marys River with Lake Huron and the St. Clair - Detroit Rivers with Lake Erie. Therefore, there is no known "double counting" in the data. For any of a number of reasons, principally because this data was hand tabulated from individual Corps district reports while the time series data of total

TABLE 37. SUMMARY OF MAINTENANCE EXPENDITURES AT U.S. HARBORS IN FISCAL YEAR 1990.

	Maintenance	Major Rehabilitation	Diked Disposal	Total Expenditures
Lake Superior				
Commercial Harbors	$7,628,170	$ 49,547	0	$7,677,717
Associated Rivers & Channels	0	0	0	0
Recreational Harbors	620,588	0	0	620,588
Total Lake Superior	8,248,758	49,547	0	8,298,305
Lake Michigan				
Commercial Harbors	12,271,880	164,887	0	12,436,767
Associated Rivers & Channels	2.2504,598	0	0	2,504,598
Recreational Harbors	704,501	0	0	704,501
Total Lake Michigan	15,480,979	164,887	0	15,645,866
Lake Huron				
Commercial Harbors	2,300,101	0	0	2,300,101
Associated Rivers & Channels	2,128,629	0	0	2,128,629
Recreational Harbors	228,745	0	0	228,745
Total Lake Huron	4,657,475	0	0	4,657,745
St. Clair & Detroit River System Associated Rivers& Channels	246,809	0	143,493	390,302
Lake Erie				
Commercial Harbors	15,052,422	0	0	15,052,422
Associated Rivers & Channels	None	None	None	None
Recreational Harbors	352,507	0	0	352,507
Total Lake Erie	15,404,929	0	0	15,404,929
Lake Ontario				
Commercial Harbors	1,349,864	0	0	1,349,864
Associated Rivers & Channels	None	None	None	None
Recreational Harbors	437,375	0	0	437,375
Total Lake Ontario	1,787,239	0	0	1,787,239
Connecting Rivers and Channels				
St. Marys River	11,046,875	0	0	11,046,875
Straits of Mackinac	650	0	0	650
St. Clair & Detroit River Connecting Channel	5,780,132	0	307,351	17,135,008
Total Connecting Rivers and Channels	16,827,657	0	307,351	17,135,008
System Total				
Commercial Harbors	38,602,436	214,434	0	38,816,870
Associated Rivers & Channels	4,880,036	0	143,493	5,023,529
Recreational Harbors	2,343,716	0	0	2,343,716
Connecting Rivers and Channels	16,827,846	0	307,351	17,135,008
Total	$62,654,034	$ 214,434	$450,844	$63,319,123

Source: Fiscal Year 1990 Annual Report of the Secretary of the Army on Civil Works Activities: Buffalo District, Chicago District and Detroit District.

expenditures were obtained from a computerized data base, the value of total O&M expenditures presented in Table 37 differs slightly from that presented in Table 34.

For each lake, expenditures have been aggregated into "Commercial Harbors, Associated Rivers and Channels," and "Recreational Harbors". As noted in Chapter 6, the former are harbors with waterborne commerce in 1984-1989, the latter are harbors without commercial receipts or shipments, regardless of authorized purpose. The Associated Rivers and Channels are canalized rivers that flow into a commercial harbor. They are few in number and of no great significance to commercial navigation on the Great Lakes. They are not to be confused with "Connecting Rivers and Channels", which are of great significance to commercial navigation on the Great Lakes.

It is obvious from the above data that the great bulk of FY 1990 O&M funds were expended for normal maintenance, which accounted for 98.9% of the total expenditure of $63.3 million. To a degree this is a tautology because in the Corps' accounting system, normal maintenance refers to operations and maintenance.

"Maintenance" includes operation and maintenance of locks and dams as well as maintenance of channels and harbors. On the Great Lakes, most maintenance expenditures are for channel dredging and harbor jetty repairs. These costs not only include the cost of the dredging and repair contracts awarded (the actual out-of-pocket costs) but also include the Corps' costs incurred in administering the program.

Major rehabilitation refers to maintenance expenditures on physical structures in excess of $5.0 million. However, as the expenditure may be made over a period of time greater than a year, a small portion of "Rehab Costs" may carry over into a subsequent year. That appears to be the reason that major rehabilitation expenditures are much less than $5.0 million; the total of such costs only amounts to $241,434.

The diked disposal expenditures are somewhat misleading as they refer to operation and maintenance expenditures made in support of the Corps' confined disposal facilities (CDF) program on the Great Lakes. Most such expenditures are included under normal maintenance. Only those charges attributable to the legislation that initially authorized construction of the CDFs are reflected in diked disposal expenditures.

Of the total 1990 O&M Expenditures of $63.3 million, 96.3% ($61.0 million) was expended in support of commercial navigation. The remaining 3.7% ($2.3 million) was spent to support recreational boating.

Of the $61.0 million expended in support of commercial navigation, 63.6% ($38.8 million) was spent in commercial

harbors. About 8.4% ($5.0 million) was spent on associated rivers and channels, which are presumed to be commercial. An additional 28.6% ($17.1 million) was expended on connecting channels. Of the $17.1 million spent on connecting channels, 64.5% ($11.0 million) was spent in maintaining the St. Marys River and the Soo Locks. The remaining 35.5% ($6.0 million) was spent to maintain the St. Clair - Detroit River system.

From an individual lake perspective, two lakes, Michigan ($15.6 million) and Erie ($15.4 million), received the most funds. The three remaining lakes, Superior ($8.3 million), Huron ($4.7 million) and Ontario ($1.8 million) received significantly smaller funds. It is to be emphasized that O&M expenditures are based upon "need" and thus it may be presumed that the "need" in Lake Erie is much greater than the "need" in Lake Ontario. Of course, the level of expenditures in itself does not address the question of how well the "need" is being satisfied. That is a larger, much more complex question that is difficult to address.

ANNUAL O&M EXPENDITURES AND HARBOR ACTIVITY

With the availability of data on tons shipped by harbor and Federal expenditures for O&M by harbor, it is possible to create an index of O&M Expenditures per ton shipped for all commercial harbors on the Great Lakes. Before reviewing the data it is necessary to point out three problems with the data.

First, there is a fundamental incompatibility between the statistics of net tons of materials transported on the Great Lakes as reported in the Gray Book and the tonnages presented in the preceding discussion of commodity flows, which form the basis of the following discussion. Succinctly stated, net tons shipped are a statistical construct; in reality, a "net ton shipped" does not exist. What does exist are commodity flows; shipments of a specific amount of a commodity from one harbor (a shipment) to another harbor (a receipt).

The second problem is one of double counting. Every shipment has a port of origin and a port of destination. Putting international imports and exports aside, every domestic shipment is thus counted twice; once as a shipment at the port of origin and once as a receipt at the port of destination. The commodity is shipped from one harbor and it is received at another. Both harbors do exist and both harbors must be maintained. There can be no shipment without a destination and there can be no receipt without an origin.

The third problem relates to time. What is the "correct" time frame (length of time in years) that should be used in reviewing O&M expenditures at harbors? O&M expenditures are a mix of funds for dredging and for rehabilitation of structures. The mix between the two purposes varies from harbor to harbor and,

for any one harbor, it varies from year to year. An additional complexity is that not all commercial harbors are dredged yearly; some are dredged every other year and others are dredged less frequently than that. In truth except for the largest commercial harbors, there is no fixed dredging schedule. Dredging schedules depend upon a number of factors including "need", budgetary considerations and others.

There is no "correct" time frame over which O&M expenditures should be averaged in developing an index of O&M expenditures per ton of freight transported to/from individual harbors. Too short of a time frame, or selection of a period in which a harbor received a major rehabilitation project, can produce a value which is deceptively high. Too long a time frame, or selection of a period designed to avoid the incidence of a major rehabilitation, can produce a value which is deceptively low. The problem is particularly acute when comparing expenditures per ton across numerous harbors as is done in this report. Here the time frame must be consistent and it must be "reasonable".

To minimize the third problem, both expenditures and tonnages have been averaged over a six-year period. The most recent six-year period that can be analyzed is 1984 to 1989.

Data on average O&M expenditures per ton of commodity shipped for the 1984-89 period for all commercial harbors on the Great Lakes are presented in Table 38. It should be noted that the values are average annual tons and average annual maintenance expenditures. The monetary values are expressed in constant 1990 dollars.

In reviewing the data in Table 38 the reader should keep in mind the problems specified above. The reader should also remember that a different time frame might well produce different results. In preparing this report both a three year (1987-1989) and a six year (1984-89) time frame were used but only the six year data are presented. Although the values for individual harbors varied with the two data sets, the overall pattern was not significantly affected.

TABLE 38. AVERAGE ANNUAL TONS, MAINTENANCE EXPENDITURES AND AVERAGE EXPENDITURES PER TON AT U.S. GREAT LAKES HARBORS, 1984-89

(Constant 1990 Dollars)

Lake and Harbor	1984-1989 Federal Ports Only Total Tons	Total Expenditures 1984 to 89 1990 $	Average Expenditures Per Ton 1984 to 89 1990 $
Lake Superior			
Major Harbors			
Ashland Harbor, Wisc.	913,132	981,437	1.07
Marquette Harbor, Mich.	2,831,990	573,744	0.20
Presque Isle Harbor, Mich.	51,674,371	383,777	0.01
Silver Bay, Minn. *			
Duluth-Superior Harbor, Minn. & Wis.	217,495,758	30,782,268	0.14
Taconite Harbor, Minn. *			
Two Harbors, Minn.	53,982,632	427,470	0.01
Subtotal	321,897,883	33,148,696	0.10
Minor Harbors			
Bayfield Harbor, Wis.	192,986	404,693	2.10
La Pointe Harbor, Wis	220,786	20,267	0.09
Ontonagon Harbor, Mich.	1,143,510	3,948,792	3.45
Washington Harbor, Minn.	40	0	0.00
Grand Portage, Minn. *	0	0	0.00
Munising Harbor, Mich. *	0	0	0.00
Oak Island, Minn. *	0	0	0.00
Keweenaw Waterway, Mich.	664,958	7,770,514	11.69
Subtotal	2,222,280	12,144,267	5.46
Total Lake Superior	324,120,163	45,292,963	0.14
Lake Michigan			
Northern Lake Michigan			
Major Harbors			
Escanaba, Mich. *			
Green Bay Harbor, Wis.	11,536,226	12,955,933	1.12
Ludington Harbor, Mich.	6,196,191	5,109,972	0.82
Petoskey, Penn Dixie Harbor *			
Port Inland, Mich. *			
Traverse City Harbor, Mich.	1,579,530	0	0.00
Subtotal	19,311,947	18,065,905	0.94
Minor Harbors			
Algoma Harbor, Wis.	10,328	0	0.00
Cedar River Harbor, Mich.	7,205	0	0.00
Charlevoix Harbor, Wis.	1,988,986	3,674,843	1.85
Frankfort Harbor, Mich.	381,132	866,794	2.27
Gladstone Harbor, Wis.	614,151	0	0.00
Kewaunee Harbor, Wis.	1,865,006	2,815,227	1.51
Mackinaw City Harbor, Mich.	1,005,671	0	0.00
Manistee Harbor, Mich.	1,581,309	3,223,130	2.04

Table 38 (Continued)

Lake and Harbor	1984-1989 Federal Ports Only	Total Expenditures 1984 to 89	Average Expenditures Per Ton 1984 to 89
Lake Michigan (Continued)	Tons	1990 $	1990 $
Manistique Harbor, Mich.	64,881	225,659	3.48
Manitowoc Harbor, Wis.	1,275,650	2,107,131	1.65
Menominee Harbor, Mich-Wis	822,243	836,822	1.02
Pensaukee Harbor, Wis.	5,367	13,866	2.58
St. James (Beaver Island), Mich	26,696	0	0.00
Sturgeon Bay(LMSC) Wis.	834,098	0	0.00
Two Rivers Harbor, Wis.	45,567	759,533	16.67
St. Ignace, Mich.	25,515	0	0.00
Detroit Harbor, Wis.	38,172	0	0.00
Wells, Mich. *			
Gills Rock, Wis. *			
Northport, Wis.	5,996	0	0.00
Subtotal	10,597,973	14,523,006	1.37
Subtotal-Northern Lake Michigan	29,909,920	32,588,912	1.09
Southern Lake Michigan			
Major Harbors			
Buffington Harbor, [Gary] Ind.*			
Burns Waterway Harbor, Ind.	46,975,720	1,993,765	0.04
Port Of Chicago, Ill.	137,798,799	28,244,375	0.20
Gary Harbor, Ind. *			
Grand Haven Harbor, Mich.	8,336,263	11,318,821	1.36
Holland Harbor, Mich.	2,163,281	11,324,252	5.23
Indiana Harbor, Ind.	87,165,905	4,729,234	0.05
Milwaukee Harbor, Wis.	14,135,349	21,316,224	1.51
Muskegon Harbor, Mich.	7,892,475	4,192,225	0.53
St. Joseph Harbor, Mich.	2,493,937	9,480,240	3.80
Waukegan Harbor, Ill.	2,620,081	3,367,469	1.29
Subtotal	309,571,810	95,966,605	0.31
Minor Harbors			
Sheboygan Harbor, Wisc.	4,995,664	3,041,013	0.61
Kenosha Harbor, Wis.	213,744	2,740,496	12.82
Michigan City Harbor, Ind.	733	1,889,692	2,578.02
Port Washington Harbor, Wis.	1,402,955	99,520	0.07
Subtotal	6,613,096	7,770,721	1.18
Subtotal-Southern Lake Michigan	316,184,906	103,737,326	0.33
Total-Lake Michigan	346,094,826	136,326,238	0.39
Lake Huron			
Major Harbors			
Alabaster Harbor, Mich. *			
Alpena Harbor, Mich.	13,693,178	653,943	0.05
Calcite Mich. *			

Table 38 (Continued)

Lake and harbor	1984-1989 Federal Ports Only	Total Expenditures 1984 to 89	Average Expenditures Per Ton 1984 to 89
Lake Huron (Continued)			
	Tons	1990 $	1990 $
Stoneport, Mich. *			
Drummond Island, Mich. *			
Port Dolomite, Mich. *			
Port Gypsum, Mich. *			
Cheboygan Harbor. Mich.	766,038	16,485	0.02
Saginaw River, Mich.	23,948,408	19,000,055	0.79
Subtotal	38,407,624	19,670,483	0.51
Minor Harbors			
Harbor Beach, Mich.	579,638	4,672,342	8.06
Harrisville Harbor, Mich.	85,441	316,233	3.70
Mackinac Harbor, Mich.	181,556	1,899,623	10.46
Sault St. Marie, Mich.	410,425	0	0.00
Detour, Mich.	3,674	411,857	112.10
	1,260,734	7,300,055	5.79
Total-Lake Huron	39,668,358	26,97[illegible]	0.68
St Clair And Detroit Rivers			
Major Harbors			
Port Of Detroit, Mich.	98,524,354	3,743,346	0.04
Marysville, (St. Clair River).	1,857,733	0	0.00
Marine City, Mich.(St Clair)	2,133,039	0	0.00
Port Huron, Mich.(St. Clair)	3,950,312	0	0.00
St. Clair, Mich.(St Clair River)	42,583,348	7,636,406	0.18
Total-St. Clair & Detroit Rivers	149,048,786	11,379,752	0.08
Lake Erie			
Major Harbors			
Ashtabula Harbor, Ohio	52,992,025	4,224,035	0.08
Buffalo Harbor, New York	10,164,917	23,555,657	2.32
Cleveland Harbor, Ohio	[illegible]2,028,702	34,731,698	0.42
Conneaut Harbor, Ohio	55,640,356	2,687,514	0.05
Erie Harbor, Pa.	5,335,068	5,054,408	0.95
Fairport Harbor, Ohio	13,728,549	3,937,197	0.29
Huron Harbor, Ohio	6,363,948	4,083,978	0.64
Lorain Harbor, Ohio	77,153,094	6,588,874	0.09
Marblehead, Ohio *			
Monroe Harbor, Mich.	7,604,680	17,525,329	2.30
Sandusky Harbor, Ohio	26,146,619	4,510,637	0.17
Toledo Harbor, Ohio	102,814,970	24,555,617	0.24
Sub-Total	439,972,928	131,454,944	0.30
Minor Harbors			
Barcelona Harbor, N.Y.	26,066	1,863,160	71.48
Kellys Island, Ohio	46,605	0	0.00
Port Clinton Harbor, Ohio	96,733	218,871	2.26
Put-In-Bay Harbor, Ohio	30,032	0	0.00

Table 38 (Continued)

Lake and Harbor	1984-1989 Federal Ports Only	Total Expenditures 1984 to 89	Average Expenditures Per Ton 1984 to 89
Lake Huron (Continued)	Tons	1990 $	1990 $
Catawba Is., Ohio	1,795	0	0.00
North Bass Is., Ohio	856	0	0.00
Middle Bass Is., Ohio	104	0	0.00
Sub-Total	202,191	2,082,031	10.30
Total-Lake Erie	440,175,119	133,536,975	0.30
Lake Ontario			
Major Harbors			
Oswego Harbor, New York	3,206,100	844,762	0.26
Sub-Total	3,206,100	844,762	0.26
Minor Harbors			
Rochester Harbor, New York	1,455,335	7,293,181	5.01
Sub-Total	1,455,335	7,293,181	5.01
Total-Lake Ontario	4,661,435	8,137,943	1.75
St. Lawrence River			
Minor Harbors			
Ogdensburg Harbor, New York	609,981	20,187	0.03
Total-St Lawrence River	609,981	20,187	0.03
SYSTEM TOTAL	1,304,378,668	361,664,594	0.28

Source: Waterborne Commerce Of The United States, Part 3, Waterways and Harbors, 1986, 1987, And 1988. COEMIS Historical Data On Annual Maintenance Costs.

O&M REVENUES: THE HARBOR MAINTENANCE FEE

Construction, operation and maintenance of federal improvements to harbors and waterways, including channels, jetties, and locks, have been the responsibility of the U.S. Corps of Engineers. Historically, all Corps expenditures involved were funded by appropriations from the Federal General Fund. The concept of user charges to defray part of the cost of Corps work was introduced by the Inland Waterways Revenue Act of 1978 (P.L. 95-502). It imposed fuel taxes on commercial inland waterways vessels to provide funds for construction of inland waterways improvements. The Water Resources Development Act of

1986 (P.L. 99-662) extended the user fee concept by requiring direct non-federal contributions to the construction costs of all other federal harbor and waterway improvements, including the Great Lakes, and imposed an ad valorem fee on commercial cargoes loaded or unloaded wherever federal funds have been expended since 1977 for harbor or channel maintenance, subject to certain exemptions described hereinafter.

The harbor maintenance fee applies on the Great Lakes and at most coastal ports. The fee applies to waterborne imports and exports, and to domestic waterborne cargoes unloaded. The fee on domestic commerce is limited to cargoes unloaded to avoid imposition of two fees on any one cargo movement. Domestic commerce subject to inland waterways fuel taxes, and certain domestic offshore commerce to/from U.S. island possessions are exempted from the fee. The 1986 law also created a Harbor Maintenance Trust Fund to receive and hold fund revenues at interest, and contained special provisions whereby revenues and expenses of the St. Lawrence Seaway Development Corporation are flowed through the Trust Fund. In effect, this integrated user fees on the U.S. portion of the Seaway with user fees on U.S. harbors and waterways; hence the harbor maintenance fee is of special significance to Great Lakes interests.

Funds in the Harbor Maintenance Trust Fund consist of ad valorem fee revenues, revenues of the St. Lawrence Seaway Development Corporation (Seaway tolls), and interest earned on Fund balances. The initial authorized purposes for disbursements from the Fund, under the 1986 law, were to pay: (1) "up to 40% of the Corps of Engineers'harbor operation and maintenance (O&M) costs, including O&M costs associated with Great Lakes navigation projects,"; (2) the cost of operating the St. Lawrence Seaway Development Corporation; and, (3) reimburse commerce subject to the ad valorem fee and Seaway tolls for the U.S. portion of the tolls.

The initial fee level, set in the 1986 law, was 0.04 percent of cargo value. This levy was intended to recover 40 percent of the Corps harbor operation and maintenance expenditures for commercial navigation, or about $160 million, based on expenditures of $400 million. Collections in FY 1989 amounted to $163.7 million. Actual eligible expenditures reimbursed to the U.S. Treasury were $159.0 million. In 1990, the fee level and use of the Fund were modified by legislation. Public Law 101-508, Section 11216, increased the fee level to 0.125 percent of cargo value, effective 1 January 1991. Public Law 101-640 provided that the Fund may now be used to pay "up to 100 percent of the eligible operations and maintenance costs assigned to commercial navigation of all harbors and inland harbors within the United States". Certain additional uses for the higher fee were contemplated, subject to authorizing legislation.

The 0.125 percent fee level is intended to cover four components: (1) Corps of Engineers expenditures at 100% recovery; (2) about $45.5 million, or more accurately a recovery level of 0.01%, for expenditures by the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA); (3) approximately $11 million to cover the administrative costs of the St. Lawrence Seaway Development Corporation; and, (4) the cost administering the harbor maintenance fee program by the Treasury Department (Customs Service) at a level of $5 million per year. Although the 0.125 percent fee now applies, disbursements to NOAA and Treasury have not yet been authorized. As a result, the balance in the Trust Fund has grown.

The Harbor Maintenance Fee (HMF) fee is paid by importers, exporters and domestic shippers to the U.S. Customs Service. Ports do not pay the fee. There is no relationship between the amount of money collected on cargo transiting a given port and the amount of money spent on operations and maintenance at that port by the Corps of Engineers.

The definition of "eligible operation and maintenance costs assigned to commercial navigation" is based upon the Corps of Engineers Management Information System (COEMIS), which is the Corps system of accounting codes used to differentiate expenditures. The vast majority of expenditures made from the HMTF is for cost code 633, Channel and Canal Maintenance.

The collected funds go into the Harbor Maintenance Trust Fund as authorized under Section 210 of Title 14 of the Water Resources Development Act of 1986. At the end of the Fiscal Year, the Department of Treasury notifies the Corps as to the amount of fees collected and the balance of the Trust Fund. The Corps then compares that amount against the previous year's eligible expenditures and authorizes the transfer of 100% of that amount.

Data on historic receipts to and expenditures from the Harbor Maintenance Trust Fund are presented in Table 39. The FY 1991 data are preliminary values, which may well become the official final values. The amount of user fee receipts collected in FY 1989 and FY 1990 is based upon the initial .04% levy. The amount collected in 1991 is based collections at the .04% levy for one quarter and collections at the .125% level for three quarters. The resulting composite levy for FY 1991 is .10375%. All things else being equal, one would expect that 1991 receipts would be approximately 260% of the 1989 and 1990 amounts. That is not the case; 1991 receipts are only about twice that of 1989 and 1990.

TABLE 39. RECEIPTS AND EXPENDITURES, HARBOR MAINTENANCE TRUST FUND: FY 1989 TO 1992.
(Millions of current dollars)

	1989	1990	1991 1/
Receipts	183.1	197.5	395.2
User fees	166.0	180.5	374.4
Seaway tolls	9.8	8.8	9.2
Interest on Investments	7.3	8.2	11.6
Expenditures	180.8	179.7	353.0
SLSDC	11.1	11.4	9.1
Corps of Engineers	159.0	159.1	333.4
SLS Toll Rebates	10.7	9.2	10.5

Source: U.S. Army Corps of Engineers, Civil Works, Program Division, Analysis Branch, Washington, D.C.

1/ The FY 1991 values are preliminary numbers; they are, however, very close to the final, official numbers. Receipts for FY 1991 are a product of three quarters of collections at the old rate (.04%) and one quarter at the new rate (.125%).

There are two possible explanations for the relatively low level of receipts in 1991. One is that the 1991 receipts reflect a lower level of commercial traffic and decreases in certain commodity values because of the 1990-91 recession. A second is that compliance, which is essentially voluntary, has been less in 1991 with the new, higher levy than it was in the previous two years. Given that 1991 was the first year the higher levy was in effect, it might well be that some users were not aware that their shipments were subject to the higher levy. While it is not known to what degree each factor has affected the relatively reduced 1991 receipts, it would appear that the relative decline is too great to be entirely explained by reduced traffic. Therefore, it appears that there is a significant compliance problem in the collection of the user fee.

Harbor Maintenance Trust Fund income statements show revenue sources by type of commerce, but do not identify the specific harbors where the tax liability was incurred. Therefore, fund revenues attributable to the Great Lakes can only be estimated. Based on the Lakes' share of the total tonnage of U.S. foreign and domestic coastwise and lakewise comemrce in 1989 (the most recent commerce statistics available) revenues attributable to Great Lakes commerce are as follows:

	Share	Amount
Domestic Commerce	26.5%	$7,953,128
Foreign Commerce	11.3%	5,951,218
Seaway Toll Receipts 1/	100.0%	9,806,418

1/ Subject to rebate if cargo is subject to harbor fee.

CHAPTER 8

CURRENT TOPICS

This chapter addresses a variety of issues that are of current interest to the commercial navigation industry on the Great Lakes. It is divided into two sections. The first a review of Confined Disposal Facilities on the lakes. The second is a brief enumeration of a number of commercial navigation projects under consideration by the Corps.

CONFINED DISPOSAL FACILITIES

A Confined Disposal Facility (CDF) is typically a submerged limestone structure, sometimes diked, constructed for the purpose of providing an enclosed area for the storage of contaminated materials obtained from dredging of harbors and channels. They act as filters, holding back fines (heavy, large molecules) while letting water pass. Discharges from municipal and industrial sources, as well as runoff from nonpoint sources, have resulted in contamination of waters and sediments in the Great Lakes. Concentrations of contaminated sediments have built up in channels and harbors of the Great Lakes. Dredging of affected harbors and channels requires that safe disposal of the material is accomplished. Placement of materials in CDF's have been seen as the most cost effective method of meeting this objective.

At present there are 37 CDF sites situated in the waters of the Great Lakes or on adjacent nearby land sites within the boundaries of the United States (Table 40). Of the 37 sites, 29 have been built in the waters of one of the Great Lakes, either as a free standing structure or as an extension of the shore or breakwater; only eight have been built at upland, inland sites.

The existing capacity of CDFs on the Great Lakes is limited and declining. Of the 37 CDF sites on the lakes, 16 are closed; that is they have been filled to their design capacity. An additional 11 are projected to be closed before the end of the decade. Only ten CDFs are projected to remain open in the year 2000, and many of them will be approaching capacity at that date. Table 41 presents a summary of the status of the CDFs on the Great Lakes.

The vast majority of CDFs constructed in the U.S. portion of the Great Lakes were constructed in the 1970s under the authorization of Section 123 of Public Law 91-611. The Federal government paid for 100% of the costs to build and maintain the structure provided that: "State or States involved, interstate agency, municipality, and other appropriate political subdivisions of the State and industrial concerns are

TABLE 40. CONFINED DISPOSAL FACILITIES ON THE GREAT LAKES, 1990

Harbor	Local Name	Type 1/	Year Const. Completed	Size (acs.)	Percent Filled	Yr. to be Closed
BUFFALO DISTRICT						
Cleveland, Ohio	Dike 10	L	1970	40	100	Closed
	Dike 12	L	1974	56	100	Closed
	Dike 14	L	1979	88	75	1994
Toledo, Ohio	Penn 7	L	1967	50	100	Closed
	Grassy Is	I	1977	150	100	Closed
	Dike 3	L	1976	242	90	1993
Buffalo, N.Y.	Small Boat Harbor	L	1968	33	100	Closed
	Dike 14	L	1977	40	55	2000
	Times Beach	L	1972	45	20	Closed
Huron, Ohio	Huron	L	1975	63	70	1993
Lorain, Ohio	Lorain	L	1977	58	45	1995
Erie, Pa.	Erie	L	1979	23	30	2000
CHICAGO DISTRICT						
Michigan City, Ind.	Michigan City,	U	1978	3	100	Closed
Chicago, Ill.	Chicago Area CDF	L	1984	42	25	2000
DETROIT DISTRICT						
Bolles Hbr., Mich.	Bolles Hbr.	L	1978	25	33	2000
Lake St. Clair, Mich.	Dickinson Island	I	1975	174	61	1998
Clinton R. Mich.	Clinton River	U	1989	30	0	2001
Clinton R. Mich.	Fisheries Site	U	1979	4	100	Closed
Detroit River, Mich.	Point Mouillee	I	1979	700	40	2009

(Table 40 continued)

Harbor	Local Name	Type 1/	Year Const. Completed	Size (acs.)	Percent Filled	Yr. to be Closed
Duluth Hbr., Minn.	Erie Pier	L	1979	82	97	1993
Grand Haven, Mich.	Harbor Island	I	1974	36	100	Closed
Green Bay, Wis.	Bayport	L	1965	400	2/	Unknown
Green Bay Wis.	Renard Island	I	1979	60	90	1992
Holland Mich.	Riverview	L	1978	11	100	Closed
Holland Mich.	Windmill Island	I	1978	17	100	Closed
Emmet Co. Mich.	Inland Route	U	1982	9	32	2000
Kenosha Wis.	Kenosha	L	1975	32	100	Closed
Kewaunee Wis.	Kewaunee	L	1982	28	61	Closed
Houghton Mich.	Keweenaw Waterway	U	1987	28	23	1996
Manitowoc Mich.	Manitowoc	L	1975	24	49	2000
Milwaukee Wis.	Milwaukee	L	1975	44	88	1996
Monroe Hbr, Mich.	Sterling State Pk.	L	1983	89	20	2000
Sebewaing, Mich.	Sebewaing Mi.	U	1979	9	100	Closed
Wyandotte, Mich.	Grassy Island	I	1960	80	100	Closed
Bay City Mich.	Middle-ground	I	1978	13	100	Closed
Saginaw Mich.	Saginaw Bay	I	1978	283	78	1998
St. Joseph Hbr., Mich.	Whirlpool 3/	U	1978	14	32	1992

Source: Survey of three U.S. Army Corps of Engineers Districts: Buffalo, Chicago and

Footnotes for Table 40

1/ L - free standing structure in the lake. I - structure is built on shore at an inland site. U - structure is attached to the shoreline.

2/ There are two CDFs at this site; one is physically situated within the other. Together, they total 400 acres. The federal CDF occupies 270 of the 400 acres; the federal CDF is closed. Some, but an unknown amount, of space is available in the City of Green Bay's CDF at this site.

3/ This site, Whirlpool in St. Joseph Harbor, Mi. is a private transfer site. The Corps leases it for two years at a time from Whirlpool Corp. In essence, it is a dewatering site. After the material is dried, it is removed from this site and disposed at an inland site somewhere in the region.

TABLE 41. STATUS OF CONFINED DISPOSAL FACILITIES ON THE GREAT LAKES, SUMMER 1991

Status	Number
Unknown	1
Closed	16
Open	20
Total	37

Projected Year of Closure for Open CDFs

Year	Number
1992	2
1993	3
1994	1
1995	1
1996	2
1997	-
1998	2
1999	-
2000	4
2001	3
2002	1
2003	-
2004	-
2005	-
2006	-
2007	-
2008	-
2009	1
Total	20

Source: United States Army Corps of Engineers, Buffalo District.

participating and in compliance with an approved plan for construction, modification or rehabilitation of waste water treatment facilities and the Administrator [of the EPA] has found that applicable water quality standards are not being violated". In essence the federal government paid 100% of the construction and maintenance costs for CDFs established under Public Law 91-611.

The legal authority provided by Public Law 91-611 has expired. For construction of a CDF at a new harbor (one to be

constructed) the current authorization is Public Law 99-662, Sect. 101, par. (a) (3). For construction at an existing harbor the authority resides in the harbor's authorizing legislation and the terms of local cooperation contained in that authorization. Project authorization legislation varies from project to project and they have a variety of CDF requirements.

The need for CDF's depends upon the contaminant levels present in the sediments of harbors and channels, the need to dredge those harbors and channels, and the remaining life of existing CDF's. Long term changes in lake levels can affect dredging needs. The upper four Great Lakes have been at average to much above average levels since the early 1970's. If the lakes were to return to levels well below average, the need to dredge and properly dispose of contaminated sediments would greatly increase.

OTHER CURRENT TOPICS

The following are summaries of current commercial navigation projects/activities in the Great Lakes - St. Lawrence Seaway System. Six projects are channel and locks projects; four are harbor projects. The four harbor projects are in different stages of development by the Detroit District.

Channel and Lock Projects and Studies

St. Lawrence Seaway Additional Locks Study, New York. The Draft Final Feasibility Study investigated plans for construction of parallel locks and associated channel enlargements to complement the existing Eisenhower and Snell locks in the United States portion of the Seaway; these locks are located at Massena, New York. The draft report was completed by the Buffalo District, United States Army Corps of Engineers in 1987. Its recommendation was to terminate the study. The reason for the negative conclusion was: 1) a lack of economic justification, and 2) the perception that the Canadian Federal Government does not foresee a need for concurrent action until about 2030.

In 1987 the study schedule was extended five years to allow the Seaway's traffic to rebound from a recessionary period in the early and mid-1980s, when there was a major restructuring of the steel industry in the region. During this five year extension period the Corps was requested to prepare several updates to the draft feasibility report.

An economic update of Seaway traffic was completed in January 1989. It concluded that there had not been sufficient growth in traffic to warrant a change in the 1987 recommendations. A second economic update is scheduled to be completed in 1992. It will be used as the final decision document

to determine the need to change the recommendations in the Draft Final Feasibility Report.

In 1989 a special investigation was conducted to determine whether specified modifications to the Seaway would make it competitive with other transportation routes. This report, dated September 1989, concluded that the Seaway's current dimensions are adequate for the traffic it has the capability to capture. It also concluded that the major structural changes necessary to allow transit of larger, deeper draft vessels are not economically justified.

The last scheduled activity for the extended five year interim period is the preparation of a summary report of the investigations conducted in the interim period. This report is scheduled to be completed in July 1992; it will close the study authority.

Welland Canal Rehabilitation, St. Catherines, Ontario. The all-Canadian Welland Canal was completed in 1932 and has been in operation ever since. In 1986 the St. Lawrence Seaway Authority announced a seven year rehabilitation program designed to make the facilities operational for another 50 years. The total cost of the rehabilitation is estimated to be approximately $175 million (Canadian). About $120 million (Canadian) has been expended in the five years the rehabilitation project has been underway. The project is on schedule and should be completed for the 1993 shipping season.

Replacement Lock, Sault Ste. Marie, Michigan. The Final Feasibility Report and EIS for this project has been prepared by the Detroit District. The report is currently at the Office of the Chief of Engineers but due to the lack of an adequate local sponsor to support the project, it has not been forwarded to the Office of Management and Budget. Section 107 of the 1990 Water Resources Development Act extended the project construction authorization.

Financing the cost of the project remains a matter of concern. The Great Lakes Commission, representing the eight Great Lakes States, testified before Congress in March 1990 advocating full Federal funding of the project. The Lake Carriers Association also supports full Federal funding. The October 1991 cost estimate for the replacement lock is $280 million with the Federal share of $182 million and a non-Federal share of $98 million.

Great Lakes and St. Lawrence Seaway Study of Financing Navigation Improvements. As requested in the Water Resources Development Act of 1988, the subject study was completed in October 1990 by an independent consultant. The report was subsequently provided to the offices of the Chief of Engineers and the Assistant Secretary of the Army for Civil Works.

The report identified several alternatives by which non-Federal interests might finance their share of any new construction costs for commercial navigation projects on the Great Lakes. It also identified several mechanisms by which the non-Federal interests might recover their costs. The most promising option appears to involve a state or perhaps a regional organization such as the Great Lakes Commission in the issuance of bonds to finance the up-front, non-Federal share of the project costs. If necessary, the state or regional agency issuing the bonds would impose tolls on waterborne traffic using the project. The toll revenue would be used to redeem the bonds. Toll structures were developed in the report that could capture sufficient revenues to pay for the non-Federal share of project costs over time, but which would not to be so burdensome as to cause a significant diversion or loss of traffic.

Great Lakes Connecting Channels and Harbors. This project was authorized for construction in the Water Resources Development Act of 1990. The recommended plan consists of the following measures: (a) deepening areas along the upper St. Marys River, as well as deepening the entrance and lower harbor channels at the Duluth, Minnesota portion of the Duluth-Superior Harbor as necessary to permit a maximum safe draft for downbound vessels of 26.5 feet at Low Water Datum (LWD); (b) disposal of the estimated 267,600 cubic yards of dredged material from the upper St. Marys River in an environmentally acceptable manner by creating an island in Izaak Walton Bay to provide habitat enhancement for a Federally endangered species -- the Piping Plover; and (c) disposal of 286,500 cubic yards of dredged materials to be obtained from the deepened areas in the Lakehead upland site.

Acting together, the State of Michigan and the Lake Carriers Association have expressed their willingness to sponsor the upper St. Marys River improvements. The city of Duluth, Minnesota, has provided a letter of intent to serve as the sponsor for the Duluth Harbor improvements. The city of Superior, Wisconsin, is the identified sponsor for the Superior Harbor improvement. However, the city of Superior has not been willing to provide a formal statement of intent to cost share the Superior Harbor improvement. Therefore, the Superior portion was not included in the authorization.

The total project cost as of October 1991 is $14 million with a Federal share of $9.36 million and a non-Federal share of $4.6 million. The project is in the Preconstruction Engineering and Design Phase in the Detroit District and is scheduled for completion in January 1994.

Sault Ste. Marie Lock Operation (Navigation Season Extension), Michigan. This is a navigation operation plan investigated by the Detroit District. There are two portions of this operation plan: the extension of the navigation season at

the Soo Locks to January 31 +/- two weeks; and the early opening of the Soo Locks prior to 1 April.

A Record of Decision (ROD) has been signed that has established 15 January of each year as the fixed closing date for the Soo Locks. The ROD was distributed to the public in mid-August 1990. The remaining action is modification of the Code of Federal Regulations consistent with the ROD. Proposed revisions of 33 CFR Part 207.44 0, regulations pertaining to the operation of the locks, were submitted in August 1990 to higher authority and the final rule was published in the Federal Register on March 24, 1992 (Vol. 57, No. 57, Pages 10244-45).

The ROD was based on environmental documentation addressing extended operation of the locks at Sault Ste. Marie, Michigan including extensive physical, chemical and biological studies concentrated in the major connecting channels of the Upper Great Lakes: the St. Marys River, the St. Clair River, Lake St. Clair and the Detroit River. After review of the environmental documentation and further coordination with concerned agencies, shipping, industry, and environmental groups, it was decided to implement only part of the January 31 + /- two week alternative. The locks will be operated no later than 15 January, exclusive of emergencies. Operation from 15 January to 15 February would occur only in cases of emergencies or other extraordinary circumstances.

Funds have been authorized to conduct studies that will investigate the opening of the Soo Locks prior to 1 April. These studies will focus on vessel traffic, effects of vessels on ice processes, water quality impacts from vessels, potential impacts on fish reproduction, ferry transportation, and winter recreation. Findings are to be reported in draft and final environmental impact statements (Supplement III to the existing EIS for operations at the Soo Locks), with required public reviews over the period November 1992 to June 1993. A Record of Decision is scheduled to be signed in September 1993.

Great Lakes Harbor Projects

The Grand Haven Harbor, Michigan project was authorized in Section 202 of the 1986 Water Resources Development Act. The plan has three components: 1) dredging the existing harbor channel to a depth of 27 feet and dredging the entrance channel in Lake Michigan to a depth of 29 feet; 2) providing a new turning basin; and 3) abandoning the existing turning basin. A revaluation report will be prepared in FY92 to determine the optimal project plan to be constructed. Preconstruction engineering and design is scheduled for completion in 1995.

The Menominee Harbor and River, Michigan and Wisconsin project was authorized by the River and Harbor Act of 1960. The

current effort is a restudy of the authorized improvements to determine if it is advisable to implement them at this time. If so, the authorized project improvements will be reclassified to an "active" status and a cost-shared feasibility study will be initiated. The authorized improvements to be restudied include: deepening the outer channel in Green Bay from 23 to 26 feet; deepening the channel between the piers and in the river from 21 to 24 feet; and enlarging the area of the existing turning basin. A reconnaissance report was completed in March 1991. The local sponsor's inability to meet feasibility study cost sharing requirements at this time has put the study on hold.

The Saginaw Bay and Saginaw River, Michigan project was authorized by Section 711 of the Water Resources Development Act of 1986. The current effort is a reconnaissance study to investigate the feasibility of providing further commercial navigation improvements, including channel deepening and widening, at Saginaw Bay and Saginaw River. The reconnaissance study has been completed, with a finding of lack of economic justification, resulting in the study being terminated in early 1992.

The St. Joseph Harbor, Michigan project was authorized by a Resolution of the House Committee on Public Works, adopted 3 August 1989. The reconnaissance report completed in November, 1990 recommended further study. Based upon a preliminary investigation, a plan to deepen the existing St. Joseph River channel by two feet was found to be economically justifiable and environmentally acceptable. Certification of the reconnaissance report by higher Corps authority has been delayed pending confirmation of an upland disposal site for dredged materials. The feasibility study will be initiated when the disposal site issue has been resolved and the negotiation of a 50-50 feasibility cost sharing agreement has been successfully accomplished.

CHAPTER 9

CONCLUSIONS

This report provides data and information on the Great Lakes - St. Lawrence River navigation system, with emphasis on the U.S. commercial navigation industry and its trade on the upper four Great Lakes. Descriptions of the physical system, the U.S. and Canadian fleets operating on the system, the commodities serviced, and the U.S. harbors on the system have been provided. Other topics involving Army Corps of Engineers management of the system, especially related to operations and maintenance activities, have been covered.

During the 1980's, significant changes in commercial navigation on the Great Lakes took place. Total tonnage shipped fell 27% between 1979 and 1990. The total fleet of U.S. and Canadian vessels operating on the lakes decreased 38% between 1980 and 1990. These trends reflect a relative decline in the importance of heavy industry and the consumption of raw materials in the Great Lakes region and of the United States as a whole, compared to the commercial and service sectors of the economy.

What remains is still a substantial base of production. Steel making, agriculture, coal based generation of electricity, and commercial shipping continue within the Great Lakes Basin at a very large scale. Productivity in steel making and commercial shipping has significantly increased; what was inefficient did not survive the competitive pressures of the past decade. The importance of waterborne transportation in delivering raw materials to industry around the Great Lakes continues undiminished, despite that fact that it is taking place at levels of tonnage substantially lower than have been experienced historically.

Among the conclusions derived from the materials contained in this report are the following:

1. The near-term future (to the year 2000) of U.S. Great Lakes shipping appears to be stable. The volume of freight to be transported across the Great Lakes during the remainder of this decade will fluctuate slightly from year to year depending upon national and international economic conditions, but the industry in 2000 should be much the same as that in 1992.

2. The U.S. Great Lakes fleet is modern and efficient. The strength of the fleet lies in the thirteen Class 10 vessels, which can carry bulk cargoes long distances on the upper four Great Lakes very economically, as well as the large number of self-unloading vessels of all sizes that can efficiently service Great Lakes ports of varying channel depths and constraints.

3. <u>The Great Lakes navigation systems serves the long distance transport of low to medium value bulk materials to greatest advantage</u>. The long term health of the commercial navigation industry and system will continue to depend on the shipments of large volumes of iron ore (taconite pellets), coal, limestone, grain, and petroleum products. The competitiveness of domestic steel production in the Great Lakes basin, in particular, is enhanced by the low cost delivery of taconite pellets from Lake Superior to the lower lakes.

4. <u>Tremendous increases in transportation efficiencies have been achieved in the rail, trucking, and marine industries during the 1980's, including the Great Lakes shipping industry</u>. Large numbers of old lake vessels have been scrapped since 1980, while the average size of cargo shipments has increased greatly. Railroads, however, have become a competitive factor in the delivery of western coal to power plants south of Detroit in southeast Michigan. Competitive pressures will continue to drive all transportation modes to seek out methods of reducing the overall costs of delivering bulk cargoes.

5. <u>Solutions for disposing of contaminated dredged material from channels and harbors are needed</u>. Much of the capacity of existing Confined Disposal Facilities (CDF's) will be fully utilized by the year 2000. The expiration of the authority to construct CDF's at full Federal expense (Section 123 of PL 91-611) means that new methods of complying with environmental standards and cost sharing requirements must be developed. Scientific research is being conducted to explore other techniques and processes for the reduction, treatment, and disposal of contaminated sediments. The ARCS program (Assessment and Remediation of Contaminated Sediments) currently has several pilot projects underway in the Great Lakes region.

6. <u>The level of Federal expenditure for Operations and Maintenance on the Great Lakes has been declining</u>. Annual O&M expenditures in constant 1990 dollars have declined sharply in the past 10 to 15 years. Levels have decreased from $129 million per year over the 1977-79 period of $76.3 million per year in the 1988-90 period. This reduction reflects in part the completion of the CDF construction program after the late 1970's. These reductions should not be interpreted as meaning that O&M support has been inadequate, but it clearly reflects that economies and efficiencies have been sought in the maintenance of the Great Lakes navigation system.

APPENDIX A

Harbor Depths and Commercial Traffic in 1989

Appendix A: Commercial Harbor Tonnages By Harbor and by Depth, By Lake for the Great Lakes, 1989 [1/]

Lake/Harbor	Tonnages	Harbor Depth
Lake Superior		
Harbor Depth- Greater Than 20 Feet.		
Ashland Harbor, Wis.	120,653	27
Duluth-Superior Harbor, Minn. & Wis.	40,802,541	27
Keweenaw Waterway, Mich.	78,397	30
Marquette Harbor, Mich.	770,414	27
Presque Isle Harbor, Mich.	12,155,757	28
Silver Bay, Minn. *	60,068	30
Taconite Harbor, Minn. *	8,991,042	30
Two Harbors, Minn.	10,535,909	28

	73,514,781	
Harbor Depth- Between 15 And 20 Feet.		
Munising Harbor, Mich. *	23,425	20
Ontonagon Harbor, Mich.	159,711	16

	183,136	
Harbor Depth- Less Than 15 Feet.		
Bayfield Harbor, Wis.	94,782	10
Grand Portage, Minn. *	40	12
La Pointe Harbor, Wis	85,918	8
Oak Island, Minn. *	331	18
Washington Harbor, Minn.	40	13

	181,111	
Total Lake Superior	73,879,028	

Appendix A - Continued

Lake/Harbor	Tonnages	Harbor Depth
Lake Michigan		
Harbor Depth- Greater Than 20 Feet.		
Buffington Harbor, [Gary] Ind.*	994,695	28
Burns Waterway Harbor, Ind.	8,695,318	28
Charlevoix Harbor, Wis.	1,455,688	23
Escanaba, Mich. *	6,767,196	28
Frankfort Harbor, Mich.	72,361	24
Gary Harbor, Ind. *	8,305,159	28
Gladstone Harbor, Wis.	94,413	24
Grand Haven Harbor, Mich.	1,333,190	21
Green Bay Harbor, Wis.	1,546,870	24
Holland Harbor, Mich.	351,220	21
Indiana Harbor, Ind.	14,385,047	28
Kenosha Harbor, Wis.	6	25
Ludington Harbor, Mich.	1,179,200	27
Manistee Harbor, Mich.	324,698	23
Manitowoc Harbor, Wis.	217,849	23
Menominee Harbor, Mich-Wis	128,878	24
Milwaukee Harbor, Wis.	2,379,208	27
Muskegon Harbor, Mich.	1,876,856	27
Port Inland, Mich. *	3,458,287	25
Port Of Chicago, Ill.	23,445,821	27
Port Washington Harbor, Wis.	172,672	21
Sheboygan, Wisc.	72,870	21
Sturgeon Bay(LMSC) Wis.	2,866	22
St. Ignace, Mich.	25,515	21
St. Joseph Harbor, Mich.	385,508	21
Wells, Mich. *	57,044	28

	77,728,435	

Appendix A - Continued

Lake/Harbor	Tonnages	Harbor Depth
Harbor Depth- Between 15 And 20 Feet.		
Kewaunee Harbor, Wis.	240,947	20
Manistique Harbor, Mich.	0	18
Michigan City Harbor, Ind.	0	18
Traverse City Harbor, Mich.	212,485	14
Waukegan Harbor, Ill.	470,047	18

	923,479	
Lake Michigan		
Harbor Depth- Less Than 15 Feet.		
Algoma Harbor, Wis.	0	14
Cedar River Harbor, Mich.	0	8
Detroit Harbor, Wis.	6,025	14
Gills Rock, Wis. *	29	12
Mackinaw City Harbor, Mich.	186,301	8
Northport, Wis.	5,996	12
Pensaukee Harbor, Wis.	0	8
Petoskey, Penn Dixie Harbor *		14
St. James (Beaver Island), Mich	3,535	14
Two Rivers Harbor, Wis.	0	13

	201,886	
Total Lake Michigan	78,853,800	

Appendix A - Continued

Lake/Harbor	Tonnages	Harbor Depth
Lake Huron		
Harbor Depth- Greater Than 20 Feet.		
Alabaster Harbor, Mich. *	492,923	23
Alpena Harbor, Mich.	2,397,107	21
Calcite Mich. *	9,238,094	28
Cheboygan Harbor, Mich.	143,436	21
Drummond Island, Mich. *	819,870	24
Harbor Beach, Mich.	97,534	21
Mackinac Harbor, Mich.	16,002	10
Port Dolomite, Mich. *	3,635,510	27
Saginaw River,Mich.	4,673,985	27
Sault. Ste. Marie, Mich.	29,377	25
Stoneport, Mich. *	8,887,828	26

	30,431,666	
Harbor Depth- Between 15 And 20 Feet.		
Port Gypsum, Mich. *	457,102	19
Lake Huron		
Harbor Depth- Less Than 15 Feet.		
Detour, Mich.	2,593	8
Harrisville Harbor, Mich.	0	10

	2,593	
Total Lake Huron	30,891,361	

Appendix A - Continued

Lake/Harbor	Tonnages	Harbor Depth
St Clair And Detroit Rivers		
Harbor Depth- Greater Than 20 Feet.		
Port Of Detroit, Mich.	20,700,867	27
Marine City, Mich.(St Clair)	327,503	22
Marysville, (St. Clair River)	558,896	24
Port Huron, Mich.(St. Clair)	1,034,052	22
St. Clair, Mich.(St Clair Rvr)	5,756,194	30

Total-St. Clair & Detroit Rivers	28,377,512	
Lake Erie		
Harbor Depth- Greater Than 20 Feet.		
Ashtabula Harbor, Ohio	10,322,455	28
Cleveland Harbor, Ohio	14,687,619	28
Conneaut Harbor, Ohio	8,889,518	28
Erie Harbor, Pa.	733,506	28
Fairport Harbor, Ohio	2,634,271	27
Huron Harbor, Ohio	590,085	28
Lorain Harbor, Ohio	14,568,175	30
Marblehead, Ohio *	912,141	22
Monroe Harbor, Mich.	1,489,864	21
Port of Buffalo, New York	2,145,188	28
Sandusky Harbor, Ohio	4,485,328	25
Toledo Harbor, Ohio	14,805,833	28

	76,263,983	

Appendix A - Continued

Lake/Harbor	Tonnages	Harbor Depth
Lake Erie		
Depth-Less Than 15 Feet.		
Barcelona Harbor, N.Y.	0	8
Catawba Is., Ohio	1,795	8
Kellys Island, Ohio	6,256	12
Middle Bass Is., Ohio	104	8
North Bass Is.,Ohio	856	8
Port Clinton Harbor, Ohio	15,316	10
Put-In-Bay Harbor, Ohio	1,704	14
	26,031	
Total Lake Erie	76,290,014	
Lake Ontario		
Harbor Depth- Greater Than 20 Feet.		
Oswego Harbor, New York	745,842	25
Rochester Harbor, New York	224,088	23
Total Lake Ontario	969,930	
St. Lawrence River		
Harbor Depth- Greater Than 20 Feet.		
Ogdensburg Harbor, New York	135,252	21

(1) The total tonnage for a lake is the sum of the tonnages at all harbors on lake. This data can be misinterpreted because it contains a considerable amount of double counting. The reader should refer to the text for elaboration on the double counting problem.

* indicates a private harbor.

APPENDIX B

Annual Federal O&M Expenditures by Harbor: 1977-1992

Appendix B- Annual O & M Expenditures By Harbor, 1977 - 1992

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Lake Ontario																
44037 CAPE VINCENT HBR	0.00	11.40	31.20	75.10	1,287.20	89.70	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
6860 GT SODUS BAY HBR	152.50	27.50	2.40	0.60	15.50	0.40	0.00	6.60	3.40	7.40	82.08	3.02	0.00	0.00		
8220 IRONDEQUOIT BAY, NY											1.80	364.90	21.56	9.28		
27013 LITTLE R NY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
9970 LITTLE SODUS BAY	44.10	413.50	35.10	0.60	15.50	4.00	0.04	1.00	11.00	2.80	48.62	1.58	0.00	19.73		
74079 MORRISTOWN HBR NY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
74081 NIAGARA R NY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
12980 OAK ORCHARD HBR N	0.00	16.00	17.10	3.90	8.10	1.70	0.00	0.10	24.00	84.01	44.75	0.25	10.00	0.00	150.00	150.00
13130 OGDENSBURG HBR NY	131.60	326.60	9.20	2.70	70.00	17.40	0.23	0.00	0.00	17.47	4.93	0.00	0.40	0.00		
44066 OLCOTT HBR NY	0.00	18.30	6.80	12.60	8.70	15.90	0.00	0.00	67.20	(6.62)	19.93	0.07	12.00	0.00	145.00	145.00
13440 OSWEGO HBR NY	285.50	37.20	70.40	31.60	34.90	632.80	558.44	111.20	16.10	0.00	553.43	64.57	0.00	327.88	405.00	327.88
15390 ROCHESTER HBR NY	816.60	734.30	576.40	575.10	854.20	598.90	1,106.23	2,069.10	422.60	1,734.84	721.36	1,266.28	77.14	1,018.15	801.00	799.60
73935 SACKETS HBR NY	0.00	10.00	1.00	3.00	6.10	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
73938 WILSON HBR NY	100.10	7.00	2.10	3.90	18.80	12.00	0.00	0.00	263.70	3.30	0.00	0.00	12.00	0.00	230.00	230.00
Subtotal	1,530.40	1,601.80	751.70	709.10	2,319.00	1,373.70	1,665.40	2,188.00	808.00	1,843.20	1,476.90	1,700.67	132.70	1,375.04	1,731.00	1,652.48

Appendix B- Annual O & M Expenditures By Harbor, 1977 - 1992

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Lake Erie																
5060	0.00	0.00	1.90	6.40	18.50	3.20	212.82	17.00	4.20	34.31	30.90	195.30	164.70	249.58	225.00	
650 ASHTABULA HBR OH	428.40	222.60	277.00	744.10	780.70	(49.60)	673.84	422.40	754.10	325.49	750.11	608.84	900.68	728.51	267.00	414.00
44036 BARCELONA HBR NY	0.00	11.80	17.60	19.60	291.60	9.30	87.88	1,488.70	36.60	0.00	0.00	0.00	2.00	0.00		
1660 BL ROCK CH TONAW	1,216.30	1,338.30	1,128.50	803.10	990.60	1,624.60	820.82	1,688.30	2,452.00	2,713.92	1,960.97	2,007.90	734.62	1,070.27	3,122.00	2,396.20
87750 BOLLES HARBOR MI									12.20	0.00	145.48	330.20	141.63	0.00	253.00	216.00
2140 BUFFALO HBR NY	3,213.60	1,126.70	1,247.40	938.20	780.70	2,452.60	1,033.85	947.40	2,043.90	1,764.63	1,536.75	2,000.06	771.92	1,467.63	1,507.00	1,447.90
73920 CATTARAUGUS CRK NY										26.30	11.90	0.02	8.02	18.91	250.00	
3430 CLEVELAND HBR OH	9,897.20	19,667.70	17,208.90	6,054.10	4,201.20	4,790.20	4,476.78	6,057.20	5,374.20	6,734.50	3,450.54	5,289.47	3,440.65	4,433.58	3,362.00	6,702.50
3770 CONNEAUT HBR OH	151.20	121.80	130.20	185.80	511.60	604.50	1,074.71	979.70	97.50	633.85	31.31	428.61	137.87	71.96	220.00	139.00
4710 DETROIT RVR MI	5,078.00	4,938.00	14,256.00	23,197.00	19,804.50	5,762.00	8,533.91	4,551.70	8,934.30	4,110.90	4,030.90	2,673.76	4,474.62	5,012.32	2,963.00	5,000.60
5600 ERIE HBR PA	189.90	2,877.90	1,267.50	134.10	254.80	187.30	332.79	2,020.20	273.80	296.65	111.06	1,287.98	383.84	288.27	87.00	45.60
5760 FAIRPORT HBR OH	285.00	613.50	896.80	448.00	407.20	571.80	595.05	783.40	764.30	263.18	116.28	663.81	895.41	137.96	37.00	510.90
7920 HURON HBR OH	49.50	65.40	481.10	558.00	546.90	633.40	444.08	996.40	531.00	598.85	754.20	617.20	30.62	802.90	37.00	605.20
11111 KELLEY'S IS HBR O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
10060 LORAIN HBR OH	5,857.80	782.00	566.50	4[illegible]3.70	519.90	1,006.00	1,377.01	1,271.70	1,064.10	1,093.96	1,059.22	703.16	539.35	624.13	1,149.00	871.60
11760 M. 'ROE HBR MI	826.00	372.00	1,451.00	715.00	848.50	12,372.00	19,401.48	6,809.20	2,960.50	1,677.40	1,612.70	1,132.40	699.86	1,060.59	188.00	1,129.00
21540 POR. CLINTON HBR	0.00	0.00	0.00	0.00	45.00	26.80	236.51	171.10	8.40	0.00	0.00	0.00	0.00	0.00		
8185 PUT-IN-BAY HBR OH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
44072 ROCKY R HBR OH	0.00	0.00	0.00	0.00	1,667.00	8.40	1.55	13.40	390.90	238.13	0.06	0.00	12.00	27.65	250.00	27.65
15590 ROUGE RVR MI	2,140.00	1,588.00	4,873.00	4,669.00	3,625.30	632.00	673.84	859.90	841.30	694.90	2,673.42	(49.94)	1,073.68	287.12	724.00	
16260 SANDUSKY HBR OH	268.30	529.40	767.00	416.90	1,157.80	517.20	'16.51	683.50	1,191.00	813.05	624.08	157.03	437.09	1,056.37	320.00	683.50
18280 TOLEDO HBR OH	3,048.00	3,718.60	2,949.00	1,654.20	2,377.50	4,101.20	3,540.13	4,037.70	4,632.70	3,367.23	2,001.21	4,710.34	2,779.05	3,309.95		7,105.00
44003 VERMILLION HBR OH	104.20	76.00	116.10	426.50	57.70	49.50	0.00	10.00	493.50	17.54	0.00	0.00	25.00	0.00	275.00	275.00
											0.82	427.00	457.15	17.45	75.00	
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Subtotal	32,753.40	38,049.70	47,635.50	41,423.70	38,887.00	35,302.40	44,433.56	33,808.90	32,860.50	25,404.79	20,901.91	23,183.14	18,109.76	20,665.13	15,311.00	27,569.65

Appendix B- Annual O & M Expenditures By Harbor, 1977 - 1992

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Lake Huron																
76062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.10	28.69	0.00	
74196 ALPENA HBR MI	21.00	2.00	17.00	18.00	0.00	0.00	0.00	0.00	551.50	0.00	0.00	0.00	0.00	0.00	238.00	224.40
770 AU SABLE HBR MI									8.70	0.00	0.00	34.70	61.33	11.74	266.00	11.74
1110 BLACK RIVER-PORT	0.00	0.00	7.30	22.70	12.30	0.70	0.00	10.10	0.90	0.00	0.00	18.34	63.07	80.49		
74199 CASEVILLE HARBOR MI									0.00	0.00	255.01	(11.60)	0.00	0.00	168.00	168.00
74203 CHEYBOYGAN HBR MI	0.00	10.00	11.00	7.00	21.00	358.00	12.61	10.60	0.40	(18.81)	11.73	10.76	0.00	0.00	166.00	166.00
2940 CHS-LKE ST CLAIR	220.00	687.00	60.00	661.00	76.30	697.00	323.96	768.00	299.10	260.66	105.93	225.80	100.24	73.27	391.00	195.60
74201 CHS-STRTS MACKINA	0.00	0.00	0.00	0.00	0.00	0.00	53.91	1.10	0.00	0.00	0.00	0.00	0.00	0.46	213.00	0.46
3490 CLINTON RIV MI									62.60	0.00	237.10	2,098.16	1,233.00	7.67	68.00	59.00
4680 DETOUR HARBOR MI									2.60	0.37	257.00	101.80	9.72			120.00
74208 HAMMOND BAY HBR MI									58.60	9.53	0.00	6.10	0.00			
7300 HARBOR BEACH HBR	88.00	102.00	31.00	1,683.00	40.00	634.00	73.79	113.80	525.60	304.74	252.96	2,671.99	363.06	2,300.10	781.00	3,726.20
53550 HARRISVILLE HARBOR MI									13.10	3.16	257.00	8.47	0.00	0.00	151.00	151.00
48140 INLAND ROUTE MICHIGAN									90.70	60.67	85.17	60.41	63.86	29.86	19.50	18.40
74006 LEXINGTON HARBOR MI									103.00	0.00	115.30	242.54	395.77	21.07	111.00	140.90
66666 MACKINAC CITY HBR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.30	13.67	0.00	0.00	0.00	0.00		
74211 MACKINAC HARBOR M	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.75	59.60	1,656.66	2.27	0.00		
46039 PORT SANILAC HBR MI									80.90	6.90	96.70	399.71	104.26	28.15	210.00	9.29
74213 PT AUSTIN HBR MI									48.10	539.75	(58.35)	37.20	134.98	19.23		
14220 PT LOOKOUT HBR MI									291.20	1,871.20	39.49	253.90	40.24	8.17		
57420 SAGINAW RVR MI	8,008.00	9,965.00	1,844.00	2,246.00	5,167.10	2,865.00	2,119.60	5,914.50	3,086.30	888.30	2,572.40	2,124.13	1,832.93	2,311.54	4,050.00	2,479.60
76061 SEBEWAING RIVER M	189.00	136.00	1,061.00	365.00	253.00	1.00	0.00	0.00	0.00	0.00	111.12	351.94	669.91	(10.72)		337.90
17300 ST CLAIR RVR MI	436.00	534.00	766.00	429.00	389.00	840.00	1,793.00	1,259.40	1,462 50	863.96	1,519.67	1,874.08	605.74	1,001.89	910.00	656.90
17380 ST MARYS R MI	6,318.00	6,581.00	7,088.00	8,265.00	7,881.80	8,368.00	8,329.00	10,323.20	9,009.20	9,761.70	9,428.70	14,783.00	10,499.80	11,046.90	12,717.00	12,339.00
Subtotal	15,280.00	18,017.00	10,885.30	13,696.70	13,840.50	13,763.70	12,705.87	18,400.70	15,709.30	14,580.55	15,346.53	26,948.09	16,225.28	16,958.51	20,459.50	20,604.30

Appendix B- Annual O & M Expenditures By Harbor, 1977 - 1992

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Lake Michigan																	
6610		1,194.03	1,595.32	2,814.73	1,751.96	1,555.88	1,583.00	1,644.09	1,603.60	1,247.10	1,008.00	1,251.43	1,565.07	1,355.55	1,461.85	1,187.50	1,679.10
17660															143.00		
17660		555.00	428.00	247.00	69.00	75.00	167.00	116.69	77.10	260.30	923.29	121.20	266.20	271.43	252.21	699.00	510.20
74177	ALGOMA HARBOR WI	5.00	114.00	195.00	0.00	82.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
46063	ARCADIA HBR MI									263.60	144.62	387.09	283.25	2,158.21	84.18	78.00	87.00
612	BIG SUAMICO HARBOR										5.00	0.00	120.30	449.79	0.00		
87387	BURNS WATER WAY SBH									0.00	0.00	2.10	30.70	173.28	218.29	340.00	121.80
2250	BURNS WW HBR IN	215.00	406.00	40.00	1,002.00	463.50	300.60	(44.35)	4.70	70.30	169.59	58.18	190.36	1,172.82	62.05	143.00	701.30
2410	CALUMET HBR R IL	877.00	463.00	100.00	528.00	330.80	683.00	3,340.64	2,478.10	2,330.20	1,399.50	574.80	993.13	5,071.52	1,066.45	157.00	558.30
2990	CHARLEVOIX HBR MI	83.00	31.00	74.00	67.00	887.50	1,321.00	310.45	288.20	53.00	154.57	251.39	1,115.17	1,528.06	110.51	24.00	156.20
45009	CHICAGO HBR IL	97.00	185.00	107.00	257.00	261.30	563.00	1,080.12	1,447.00	653.20	1,488.15	957.04	1,053.46	1,333.94	1,527.45	1,133.00	1,947.60
3810	CHICAGO RVR IL	16.00	17.00	11.00	145.00	240.00	340.00	1,486.07	1,225.80	385.20	941.52	694.10	694.06	1,347.10	1,042.75	1,923.00	1,386.30
6130	FRANKFORT HBR MI	287.00	213.00	1,580.00	448.00	203.60	1,115.00	1,077.68	367.20	75.30	49.30	148.22	21.19	79.91	175.80	158.00	302.40
6670	GD HAVEN HBR MI	304.00	196.00	543.00	476.00	1,595.90	1,022.00	1,164.03	3,622.70	1,734.70	1,820.50	762.70	722.26	1,054.28	603.54	870.00	1,211.20
6730	GRAND TRAVERSE HB	83.00	88.00	79.00	46.00	24.10	136.00	52.04	229.20	11.80	0.00	87.58	37.66	29.76	76.81	121.00	76.81
74160	GRAYS REEF MI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.00	
6910	GREEN BAY HBR WI	762.00	2,918.00	4,111.00	454.00	1,181.10	666.00	2,005.25	1,173.40	1,459.10	1,915.80	1,590.60	2,654.66	2,804.34	1,218.81	2,066.00	1,783.20
7610	HOLLAND HARBOR MI	1,304.90	520.90	825.50	647.30	689.00	474.00	2,356.90	1,791.90	1,356.40	1,313.80	546.40	1,155.42	3,981.35	1,036.83	510.00	1,134.80
18120	INDIANA HBR IN	56.00	117.00	88.00	251.00	43.60	81.40	304.63	434.50	1,075.50	1,224.39	293.69	372.20	745.46	299.86	597.00	535.40
8910	KENOSHA HARBOR WI	252.10	75.10	95.00	79.00	62.00	266.00	79.80	380.00	89.90	168.92	1,206.02	351.86	232.83	699.77	138.00	699.77
76050	KEWAUNEE HARBOR W	111.60	162.00	104.00	61.80	2,122.00	1,141.00	607.77	400.90	218.10	225.01	159.07	962.76	562.08	251.08	317.00	468.10
74185	LB DENOC GLDSTN-K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
46018	LELAND HBR MI	98.00	87.00	92.00	100.00	39.80	71.00	177.09	235.30	62.30	104.73	100.16	138.20	128.48	120.92	117.00	172.00
10270	LUDINGTON HARBOR	102.90	28.90	33.20	101.10	279.90	447.00	726.77	544.20	1,113.50	290.80	1,804.80	578.44	134.95	570.07	510.00	2,091.70
10480	MANISTEE HARBOR M	168.00	88.80	138.10	111.70	58.30	393.00	195.90	466.70	36.30	791.53	784.45	313.52	458.20	1.43	214.00	945.40
10490	MANISTIQUE HBR MI	23.00	5.00	4.00	25.00	99.00	163.00	147.74	4.80	5.00	0.00	0.00	35.00	168.97	59.31	709.00	493.60
10510	MANITOWOC HBR WI	293.00	198.00	98.00	116.00	316.00	494.00	297.94	736.30	125.90	300.39	297.16	220.31	134.50	197.76	360.00	690.80
45044	MENOMINEE HBR MI	81.00	28.00	53.00	96.00	60.10	50.00	58.33	100.00	224.90	111.70	149.32	29.39	115.12	110.09	23.00	89.90
11060	MICHIGAN CTY HBR	145.00	830.00	565.00	121.00	82.60	17.30	(7.57)	18.70	1.30	22.48	1,115.43	279.17	275.94	847.32	52.50	138.10
11270	MILWAUKEE HBR WI	918.00	2,835.00	903.00	42.00	1,445.30	1,237.00	412.33	1,027.50	2,109.10	3,589.00	3,982.70	4,145.19	1,328.67	914.10	2,395.00	1,258.20
12060	MUSKEGON HBR MI	209.00	294.00	208.00	381.00	172.80	417.00	243.15	590.20	125.50	1,692.80	135.60	563.38	580.17	225.72	277.00	886.90
1020	NEW BUFFALO HBR MI									173.00	664.12	10.10	385.70	121.18	140.99	0.00	135.00
23370	OCONTO HBR WI	0.00	0.00	18.00	9.00	0.00	0.00	0.00	10.20	0.80	0.00	0.00	0.00	0.00	0.00	363.00	
74819	PENSAUKEE HBR WI	0.00	0.00	0.00	0.00	0.00	10.00	0.30	0.00	0.00	12.00	0.00	0.00	0.00	0.00		
13850	PENTWATER HBR MI	51.00	135.00	101.00	65.00	940.00	129.00	81.22	85.20	169.30	193.80	222.50	283.77	268.76	110.45	151.00	158.00
74170	PETOSKEY HBR MI									205.70	4.27	0.00					
21530	PORTAGE LAKE HBR	89.00	(27.00)	13.00	131.00	194.80	(8.00)	0.92	0.20	4.70	123.10	0.81	6.11	225.39	140.13		
14420	PT WASHINGTON HBR WI									6.70	(16.71)	0.00	0.00	106.50	51.20		189.30
14820	RACINE HARBOR WI	96.00	173.00	90.00	2.00	258.00	0.00	26.70	121.20	45.90	17.30	0.70	0.00	0.00	0.00		
16390	SAUGATUCK HBR MI	36.00	112.00	31.00	57.00	[illegible]	174.00	151.74	20.00	250.00	86.59	23.98	151.45	53.56	88.90		
66700	SHEBOYGAN HBR WI	247.00	92.00	340.00	126.00	237.00	250.00	238.59	1,650.10	193.10	372.70	251.60	267.38	61.11	215.79	486.00	606.10
17180	SOUTH HAVEN HBR M	55.00	11.00	27.00	(4.00)	76.00	241.00	98.97	30.10	250.10	753.90	197.20	89.10	130.53	3.26		
74219	ST JAMES HBR MI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
17350	ST JOSEPH HBR MI	473.00	502.00	341.00	275.00	446.70	793.00	778.11	733.00	786.60	1,275.10	1,191.60	3,541.03	965.85	832.81	1,016.50	1,181.30
58300	ST JOSEPH RIVER M	0.00	0.00	0.00	0.00	0.00	750.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
18710	TWO RVRS HBR WI	32.00	42.00	16.00	376.00	1,334.90	(30.00)	0.00	26.90	119.90	358.90	7.03	21.54	133.09	309.76		
19560	WAUKEGAN HBR IL	337.00	55.00	320.00	25.00	201.70	606.70	182.57	504.30	309.50	753.00	158.22	1,066.70	173.84	576.49	908.00	941.00
19810	WHITE LAKE HBR MI	23.00	1.90	24.90	5.60	0.00	127.00	63.36	13.70	404.00	527.40	145.40	150.51	194.38	34.77		273.70
	Subtotal	9,679.53	13,020.92	14,430.43	8,444.46	16,128.98	16,191.00	19,455.97	22,442.90	18,006.80	24,980.86	19,670.37	24,855.60	30,110.90	15,882.51	18,087.50	23,610.48

Appendix B- Annual O & M Expenditures By Harbor, 1977 - 1992

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Lake Superior																
630 ASHLAND HBR MI	178.00	36.00	5.00	37.00	428.80	211.00	77.49	246.90	15.10	129.60	2.20	4.70	76.10	213.75	542.00	195.40
74320 BAYFIELD HARBOR W	2.00	5.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	361.30	0.00	0.00	0.00		87.00
1410 BIG BAY HBR MI									0.00	0.00	0.00	33.10	0.00		135.00	
1640 BLACK R UPR PEN	9.90	90.90	31.20	43.80	0.00	0.00	11.00	10.90	65.00	8.70	141.90	135.45	0.25	0.03		
3970 CORNUCOPIA HBR WI	1.00	81.00	68.00	5.00	93.60	104.00	0.00	0.00	104.90	5.57	1.41	20.00	0.00	0.00	124.00	71.60
5050 DULUTH-SUPERIOR M	1,567.00	2,664.00	2,955.00	2,289.00	1,929.00	1,585.00	1,886.07	2,687.70	5,516.80	6,719.10	0.00	3,636.40	2,703.30	4,015.40	4,027.50	3,122.40
22870 EAGLE HBR MI	1.00	5.00	(2.00)	0.00	0.00	0.00	13.01	7.40	0.60	0.00	5,747.80	0.00	1.95	0.05		155.50
99871 GD MARAIS HBR MN	130.00	102.00	224.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.21	0.00		
46064 GRAND MARAIS HBR	2.00	74.00	19.00	2.00	4.00	0.00	18.26	44.20	273.40	1,071.03	0.00	16.40	0.50	175.02		
8960 KEWEENAW WW MI	279.00	470.00	20.00	134.00	506.50	408.00	423.86	420.00	509.00	888.60	(3.80)	781.79	4,594.89	2,285.29	664.00	1,166.20
48000 KNIFE RIVER HBR M	1.00	1.00	6.00	18.00	3.80	0.00	19.17	0.80	24.70	5.32	3,653.60	0.00	0.00	0.00		
9450 LA POINTE HBR WI	41.00	8.00	5.00	0.00	1.00	0.00	0.00	4.90	10.00	2.10	0.00	0.00	0.00	0.00	92.00	
9210 LAC LA BELLE HBR	0.00	5.00	43.00	(2.00)	0.00	29.00	50.75	204.80	5.00	0.00	0.00	0.00	73.00	0.00		
9890 LITTLE LAKE HBR MI									256.90	279.13	0.00	221.90	163.10	154.45	120.00	172.00
48013 MARQUETTE HBR MI	32.00	77.00	149.00	0.00	0.00	0.00	0.51	63.40	19.10	198.94	166.20	4.18	1.07	194.11	236.00	282.50
13330 ONTONAGON HBR MI	421.00	322.00	86.00	125.00	739.70	559.00	211.01	353.40	541.70	919.16	180.70	563.05	701.99	810.60	2,850.00	4,282.90
74190 PORT WING HBR WI	2.00	12.00	31.00	4.00	0.00	0.00	9.00	4.00	216.10	(41.15)	421.00	69.28	0.54	40.05	135.00	60.30
48012 PRESQUE ISLE HBR	.3.00	16.00	4.00	7.00	5.50	10.00	29.00	133.00	5.70	0.00	0.00	15.11	0.00	4.22	369.00	389.40
16500 SAXON HBR WI									24.10	22.86	176.99	59.80	135.49	107.79		
18700 TWO HBRS MN	32.00	0.00	24.00	4.00	7.00	79.00	155.17	56.70	0.00	0.00	13.80	120.52	203.74	75.81	2,635.00	418.00
48011 WARROAD HBR MN	0.00	0.00	0.00	0.00	0.00	0.00	189.66	14.10	3.00	9.60	4.77	44.72	12.11	0.00		
19850 WHITEFISH POINTE	14.00	0.00	0.00	45.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00	135.85	94.00	135.85
Subtotal	2,715.90	3,968.90	3,675.20	2,719.80	3,720.90	2,985.00	3,093.96	4,252.20	7,591.10	10,218.56	10,867.87	5,726.40	8,684.24	8,212.42	12,023.50	10,539.05
Total System	61,959.23	74,658.32	77,378.13	66,993.76	74,896.38	69,615.80	81,354.76	81,092.70	74,975.70	77,027.96	68,263.58	82,413.90	73,262.88	63,093.61	67,612.50	83,976.05

APPENDIX C

Disaggregated Federal O&M Expenditures
for
FY 1990 by Harbor

Appendix C- Dissaggregated O&M Expenditures For FY 1990 by Harbor

	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Lake Superior					
Major Commercial Harbors					
Ashland Harbor, Wis.		$213,755			$213,755
Marquette Harbor, Mich.		$194,387			$194,387
Presque Isle Harbor, Mich. (Section 111)		$4,221			$4,221
Silver Bay, Minn. *	$0	$0	$0		$0
Duluth-Superior Harbor, Minn. & Wis.		$3,965,833	$49,547		$4,015,380
Taconite Harbor, Minn. *	$0	$0	$0		$0
Two Harbors, Minn.		$75,806			$75,806
Subtotal	$0	$4,454,002	$49,547	$0	$4,503,549
Minor Commercial Harbors					
Bayfield Harbor, Wis.	N.A.	N.A.	N.A.	N.A.	$0
Black River Harbor, Mich. (U.P.)		$1,463			$1,463
Grand Traverse Harbor, Mich.		$76,808			$76,808
Keweenaw Waterway, Mich.		$2,285,292			$2,285,292
La Pointe Harbor, Wis	N.A.	N.A.	N.A.	N.A.	$0
Ontonagon Harbor, Mich.	$1,733	$810,605			$812,338
Subtotal	$1,733	$3,174,168	$0	$0	$3,175,901
Recreational Harbors					
Eagle Harbor, Mich.		$1,383			$1,383
Grand Marais Harbor, Mich.		$175,017			$175,017
Little Lake Harbor, Mich.		$154,452			$154,452
Port Wing Harbor, Wi.		$46,102			$46,102
Saxon Harbor, Wi. (Section 111)		$107,785			$107,785
Whitefish Point Harbor, Mich.		$135,849			$135,849
Subtotal	$0	$620,588	$0	$0	$620,588
Total Lake Superior	$1,733	$8,248,758	$49,547	$0	$8,300,038
Rivers & Channels					
St Marys River, Mich.	$0	$11,046,875			$11,046,875

Appendix C - Continued

Northern Lake Michigan Major Commercial Harbors	New Work	Maintenance	Rehab Costs	Diked Disposal	Cost F.Y. 1990
Escanaba, Mich. *	$0	$0	$0	$0	$0
Green Bay Harbor, Wis.		$1,153,571			$1,153,571
Ludington Harbor, Mich. (Section 111)		$570,073			$570,073
Petoskey, Penn Dixie Harbor *	$C	$0	$0	$0	$0
Port Inland, Mich. *	$0	$0	$0	$0	$0
Stoneport, Mich. *	$0	$0	$0	$0	$0
Subtotal	$0	$1,723,644	$0	$0	$1,723,644
Minor Commercial Harbors					
Algoma Harbor, Wis.	N.A.	N.A.	N.A.	N.A.	$0
Cedar River Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$C
Charlevoix Harbor, Mich.		$110,507			$110,507
Frankfort Harbor, Mich.		$175,652			$175,652
Gladstone Harbor, Wis.	N.A.	N.A.	N.A.	N.A.	$0
Kewaunee Harbor, Wis.		$251,075			$251,075
Mackinaw City Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$0
Manistee Harbor, Mich.		$27,391			$27,391
Manistique Harbor, Mich.		$59,313			$59,313
Manitowoc Harbor, Wis.		$197,759			$197,759
Menominee Harbor & River, Mich-Wis		$110,088			$110,088
Pensaukee Harbor, Wis.	N.A.	N.A.	N.A.	N.A.	$0
St. James (Beaver Island), Mich	N.A.	N.A.	N.A.	N.A.	$0
Sturgeon Bay(LMSC) Wis.		$252,213			$252,213
Two Rivers Harbor, Wis.		$309,764			$309,764
Subtotal	$0	$1,493,762	$0	$0	$1,493,762
Rivers & Channels					
Fox River, Wis.		$1,461,849			$1,461,849
	$0	$1,461,849	$0	$0	$1,461,849
Recreational Harbors					
Arcadia Harbor, Mich.		$84,180			$84,180
Leland Harbor, Mich.		$120,917			$120,917
Portage Lake, Mich.		$140,128			$140,128
	$0	$345,225	$0	$0	$345,225
Subtotal-Northern Lake Michigan	$0	$5,024,480	$0	$0	$5,024,480

Southern Lake Michigan Major Commercial Harbors	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Buffington Harbor, [Gary] Ind.*	N.A.	N.A.	N.A.	N.A.	$0
Burns Waterway Harbor, Ind.		$62,051			$62,051
Port Of Chicago, Ill.		$1,527,448			$1,527,448
Calumet Harbor, Ill.		$926,474	$139,973		$1,066,447
Gary Harbor, Ind. *	$0	$0	$0	$0	$0
Grand Haven Harbor, Mich. (Section 111)		$603,541			$603,541
Holland Harbor, Mich. (Section 111)		$1,036,828			$1,036,828
Indiana Harbor, Ind.		$299,862			$299,862
Milwaukee Harbor, Wis.		$889,184	$24,914		$914,098
Muskegon Harbor, Mich.		$225,718			$225,718
Sheboygan Harbor, Wis.		$215,787			$215,787
St. Joseph Harbor, Mich. (Section 111)		$832,807			$832,807
Waukegan Harbor, Ill.		$576,487			$576,487
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Subtotal	$0	$7,196,187	$164,887	$0	$7,361,074
Minor Commercial Harbors					
Kenosha Harbor, Wis.		$699,775			$699,775
Michigan City Harbor, Ind.		$847,323			$847,323
Pentwater Harbor, Mich.		$110,454			$110,454
Port Washington Harbor, Wis.		$53,142			$53,142
Saugatuck Harbor, Mich.		$88,838			$88,838
South Haven, Mich. (Section 111)		$14,759			$14,759
White Lake Harbor, Mich. (Section 111)		$43,996			$43,996
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Subtotal	$0	$1,858,287	$0	$0	$1,858,287
Rivers & Channels					
Chicago River, Ill.		$1,042,749			$1,042,749
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	$0	$1,042,749	$0	$0	$1,042,749
Recreational harbors					
New Buffalo Harbor, Mich.		$140,988			$140,988
Burns Waterway Small Boat, Ind.		$218,288			$218,288
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	$0	$359,276	$0	$0	$359,276
Subtotal-Southern Lake Michigan	$0	$10,456,499	$164,887	$0	$10,621,386
Total-Lake Michigan	$0	$15,480,979	$164,887	$0	$15,645,866
Straits Of Mackinac, Mi. (Channels)		$650			$650

Lake Huron Major Commercial Harbors	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Alabaster Harbor, Mich. *	$0	$0	$0	$0	$0
Alpena Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$0
Calcite Mich. *	$0	$0	$0	$0	$0
Cheboygan Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$0
Drummond Island, Mich. *	$0	$0	$0	$0	$0
Port Dolomite, Mich. *	$0	$0	$0	$0	$0
Port Gypsum, Mich. *	$0	$0	$0	$0	$0
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Subtotal	$0	$0	$0	$0	$0
Minor Commercial Harbors					
Harbor Beach, Mich.		$2,300,101			$2,300,101
Harrisville Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$0
Mackinac Island Harbor, Mich.	N.A.	N.A.	N.A.	N.A.	$0
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	$0	$2,300,101	$0	$0	$2,300,101
Rivers & Channels					
Saginaw River, Mich.	$0	$2,128,629			$2,128,629
Recreational Harbors					
Au Sable Harbor, Mich.		$11,736			$11,736
Bayport Harbor, Mich.		$28,695			$28,695
Black River Harbor (Port Huron), Mich.		$80,490			$80,490
Lexington Harbor, Mich. (Section 111)		$26,697			$26,697
Point Lookout Harbor, Mich.		$25,957			$25,957
Port Austin Harbor, Mich.	$813,539	$22,130			$835,669
Port Sanilac Harbor, Mich. (Section 111)		$28,149			$28,149
Sebewaing River, Mich.		$4,891			$4,891
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	$813,539	$228,745	$0	$0	$1,042,284
Total-Lake Huron	$813,539	$4,657,475	$0	$0	$5,471,014

St Clair And Detroit River Channels System Associated Rivers And Channels	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Clinton River, Mich.(Detroit River)		$103,183			$103,183
Rouge River Mich.(Detroit River)		$143,626		$143,493	$287,119
Port Huron, Mich.(St. Clair)					$0
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Total-St. Clair & Detroit Rivers	$0	$246,809	$0	$143,493	$390,302

St Clair And Detroit River System-Connecting Rivers & Channels

Detroit River. Mich.		$4,704,968		$307,351	$5,012,319
Lake St Clair, Mich. (Channels)		$73,273			$73,273
St. Clair River, Mich.		$1,001,891			$1,001,891
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	$0	$5,780,132	$0	$307,351	$6,087,483

Appendix C - Continued

Lake Erie Major Commercial Harbors	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Ashtabula Harbor, Ohio		$728,505			$728,505
Buffalo Harbor, New York		$1,467,633			$1,467,633
Cleveland Harbor, Ohio	$321,423	$4,433,578			$4,755,001
Conneaut Harbor, Ohio		$71,935			$71,935
Erie Harbor, Pa.		$288,593			$288,593
Fairport Harbor, Ohio		$137,961			$137,961
Huron Harbor, Ohio		$802,901			$802,901
Lorain Harbor, Ohio	$42,957	$624,133			$667,090
Marblehead, Ohio *	$0	$0	$0	$0	$0
Monroe Harbor, Mich.		$1,060,591			$1,060,591
Sandusky Harbor, Ohio		$1,056,371			$1,056,371
Toledo Harbor, Ohio		$3,309,950			$3,309,950
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Sub-Total	$364,380	$13,982,151	$0	$0	$14,346,531
Minor Commercial Harbors					
Barcelona Harbor, N.Y.	$26,010				$26,010
Black Rock Channel,Tonawanda Harbor,N.Y.		$1,070,271			$1,070,271
Kellys Island, Ohio	$3,469	$4,587	$7,793	$6,451	$22,300
Port Clinton Harbor, Ohio	$17,614	$20,802	$19,077	$18,604	$76,097
Put-In-Bay Harbor, Ohio	$6,072				$6,072
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Sub-Total	$53,165	$1,095,660	$26,870	$25,055	$1,200,750
Recreational Harbors					
Bolles Harbor, Mich.		$5,599			$5,599
Buffalo Harbor, NFTA, N.Y.	$124,284				$124,284
Cattaraugus Harbor, N.Y.		$20,256			$20,256
Dunkirk Harbor, N.Y.		$249,795			$249,795
Geneva On the Lake, Oh.	$536,389				$536,389
Rocky River, Oh.		$28,171			$28,171
West Harbor, Oh.		$46,785			$46,785
Sturgeon Point, N.Y.	$26,603	$1,901			$28,504
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Sub-Total	$687,276	$352,507	$0	$0	$1,039,783
Total-Lake Erie	$1,104,821	$15,430,318	$26,870	$25,055	$16,587,064

Lake Ontario Major Commercial Harbors	New Work	Maintenance	Rehab Costs	Diked Disposal	Total Cost F.Y. 1990
Oswego Harbor, New York		$331,713			$331,713
Sub-Total	$0	$331,713	$0	$0	$331,713
Minor Commercial Harbors					
Rochester Harbor, New York		$1,018,151			$1,018,151
Sub-Total	$0	$1,018,151	$0	$0	$1,018,151
Recreational Harbors					
Irondequoit Bay, N.Y.		$9,642			$9,642
Little Sodus Bay, N.Y.		$34,086			$34,086
N. Y. State Barge Canal, N.Y.		$373,656			$373,656
Olcott Harbor, N.Y.	$430,663	$16,465			$447,128
Port Ontario, N.Y.	$393	$3,526			$3,919
Sub-Total	$431,056	437,375	0	0	868,431
Total-Lake Ontario	$431,056	$1,787,239	$0	$0	$2,218,295
Connecting Rivers And Channels					
St. Marys River, Mich.	$0	$11,046,875	$0	$0	$11,046,875
Straits Of Mackinac, Mich.	$0	$650	$0	$0	$650
St. Clair & Detroit River Connecting Chan	$0	$5,780,132	$0	$307,351	$6,087,483
	$0	$16,827,657	$0	$307,351	$17,135,008
SYSTEM TOTAL	$2,351,149	$62,679,235	$241,304	$475,899	$65,747,587

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